

## CHAPTER 8

# PRE-ENGINEERED STRUCTURES: BUILDINGS, K-SPANS, TOWERS, AND ANTENNAS

As a Steelworker, pre-engineered metal structures are a special interest to you; you are expected to assemble and disassemble them. Rigid-frame buildings, k-spans, steel towers, and antennas are some of the more commonly used structures, particularly at advanced bases overseas.

All pre-engineered structures, discussed in this text, are commercially designed structures, fabricated by civilian industry to conform to the specifications of the armed forces. The advantage of pre-engineered structures is that they are factory-built and designed to be erected in the shortest possible time. Each pre-engineered structure is shipped as a complete building kit including all the necessary materials and instructions to erect it.

Various types of pre-engineered structures are available from numerous manufacturers, such as Strand Corporation, Pasco, and Butler; however, all are similar because each is built to military specifications. It would not be practical to try and include all of the structures that each company fabricates; therefore, in this manual a description of the basic procedures for erecting and dismantling the 40-foot by 100-foot building is provided as an example.

### PRE-ENGINEERED BUILDINGS

This chapter introduces you to the design, the structure, and the procedures for the erection of the

typical pre-engineered buildings (P.E.B.), the K-spans, the pre-engineered towers, and the antennas.

The basic pre-engineered metal building (fig. 8- 1) is 40 feet wide by 100 feet long. Although the unit length of the building is 100 feet, the length can be increased or decreased in multiples of 20 feet, which are called "20-foot bays." The true building length will be equal to the number of 20-foot bays plus 6 inches; each end bay is 20 feet 3 inches. The building is 14 feet high at the eave and 20 feet 8 inches at the ridge.

Pre-engineered buildings are ideal for use as repair shops or warehouses because they have a large, clear floor area without columns or other obstructions as well as straight sidewalls. This design allows floor-to-ceiling storage of material and wall-to-wall placement of machinery. The column-free interior also permits efficient shop layout and unhindered production flow.

After a building is up, it can be enlarged while in use by "bays", providing additional space under one roof. If desired, buildings can be erected side by side "in multiples." When a building is no longer needed it can be disassembled, stored, or moved to another location and re-erected because only bolted connections are used. There is no field riveting or welding. The rigid frame is strong. It is designed for

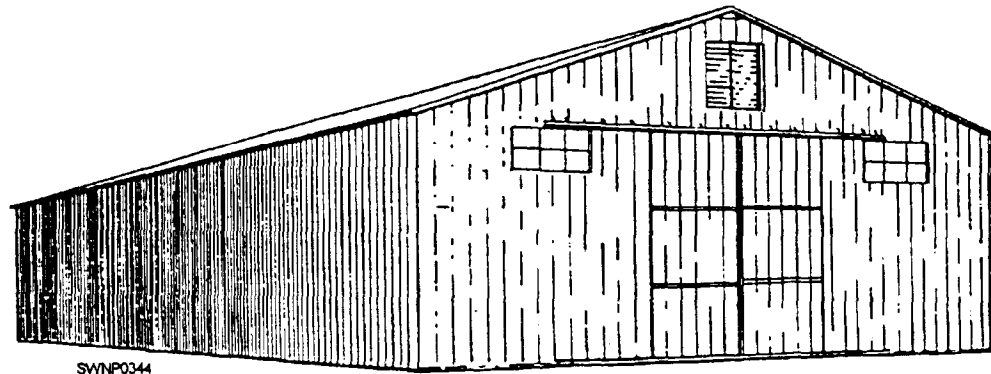


Figure 8-1.—Completed 40-foot by 100-foot by 14-foot pre-engineered building.

127.121

working loads of 20 pounds per square foot load, plus the dead load, and the load from a 70 mph wind.

The building can be easily modified to varying lengths and purposes by taking out or adding bays or by substituting various foundation and wall sections. A bay is the distance between two column centers or between the end wall and the first column center in from the end wall.

Formulas used to determine the number of bays, frames, and intermediate frames in a building are as follows:

Length divided by 20 = number of bays

Bays + 1 = total number of frames

Total number of frames - 2 = number of intermediate frames

### PRE-ERECTION WORK

Extensive pre-erection work is required before you start the actual erection of a building. After the building site is located and laid out by the Engineering Aids, it will then be cleared and leveled by Equipment Operators. Batter boards are set up in pairs where each corner of the foundation is located. Builders fabricate the forms for concrete while Steelworkers are cutting, bending, tying, and placing reinforcing steel. If this particular building requires underslab utilities (that is, plumbing and electrical service), the Utilitiesman and Construction Electricians will also be on the jobsite. Last, all underslab work must be completed and pass all Quality Control inspections before concrete is placed and finished.

Most importantly (as far as ease of erection is concerned), before the concrete is placed, templates for the anchor bolts are attached to the forms, and the anchor bolts are inserted through the holes in each.

Next, the forms are tied to make sure they remain vertical. It must be stressed at this point that the proper placement of the anchor bolts is absolutely critical in the erection of a P.E.B. You will only have a tolerance of plus or minus one eighth of an inch to work with. The threads of the bolts are greased, and the nuts are placed on them to protect the threads. Concrete is poured into the formwork and worked carefully into place around these bolts, so they will remain vertical and in place. Finally, according to the plans and specifications, the slab is poured.

While the foundation is being prepared, the crew leader will assign personnel/crews to perform various types of preliminary work, such as uncrating and inventorying all material on the shipping list, bolting up rigid-frame assemblies, assembling door eaves, and glazing windows. Box 1 contains the erection manual, the drawings, and an inventory list and should be opened first. If all of the preliminary work is done correctly, the assembly and erection of the entire building is accomplished easily and quickly.

All material, except the sheeting, should be uncrated and laid out in an orderly manner, so the parts can be located easily. Do not uncrate the sheeting until you are ready to install it. When opening the crates, use care not to cause any undue damage to the lumber. This is important since the lumber can be used for sawhorses and various other items around the jobsite.

In most situations, after the building foundation has been prepared, building materials should be placed around the building site near the location where they will be used (fig. 8-2). This action provides the greatest accessibility during assembly.

Girts, purlins, eave struts, and brace rods should be equally divided along both sides of the foundation.

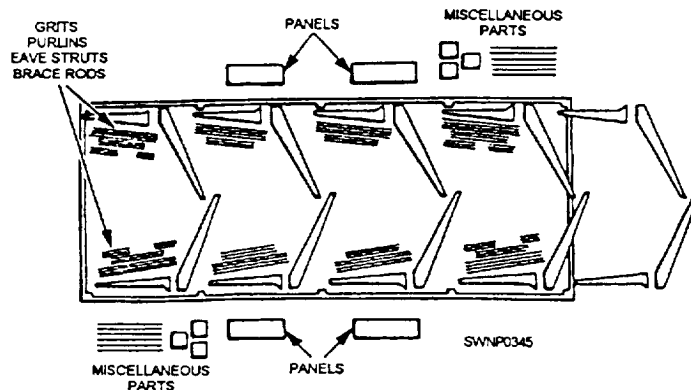


Figure 8-2.—Material layout

Panels and miscellaneous parts, which will not be used immediately, should be placed on each side of the foundation on pallets or skids and covered with tarps or a similar type of covering until needed. Parts, making up the rigid-frame assemblies, are laid out ready for assembly and in position for raising.

Care should always be used in unloading materials. Remember that damaged parts will cause delays in getting the job done. To avoid damage, lower the materials to the ground slowly and do not drop them.

Figure 8-3 will help you identify the structural members of the building and their location. Each part has a specific purpose and must be installed in the location called for to ensure a sound structure. **NEVER OMIT ANY PART CALLED FOR ON THE DETAILED ERECTION DRAWINGS.** Each of the members, parts, and accessories of the building is labeled by stencil, so it is not necessary to guess which one goes where. Refer to the erection plans to find the particular members you need as you work.

## ERECTION PROCEDURES

With all pre-erection work completed, inspected, and passed by Quality Control, as well as your inventory completed, you are ready to start erecting

the P.E.B. This phase of our discussion will introduce you to the basic erection procedures. The reason for these instructions is to give you a general guide to follow. Keep in mind that the drawings provided by the manufacturer must be followed in all cases, even where they might differ from information in this training manual. The manufacturer's standard practice is to always pack an erection manual and a set of drawings in the small parts box (Box 1) shipped with each building.

## Bolting Rigid Frames

Before bolting up the rigid-frame assembly, clean all the dirt and debris from the top of the foundation. Then lay out and bolt the base shoes firmly to the concrete, using the 5/8-inch black steel washers between the shoes and the nuts. Lay out an assembled column and roof beam at each pair of base shoes (fig. 8-4), using one 3/4-inch by 1 1/2-inch bolt on each side of each base shoe to act as pivots in raising the frame. Use driftpins, if necessary, to line up the holes.

## Frame Erection

A gin pole (chapter 6) can be used to raise the end frame of the building. To prevent distortion of the

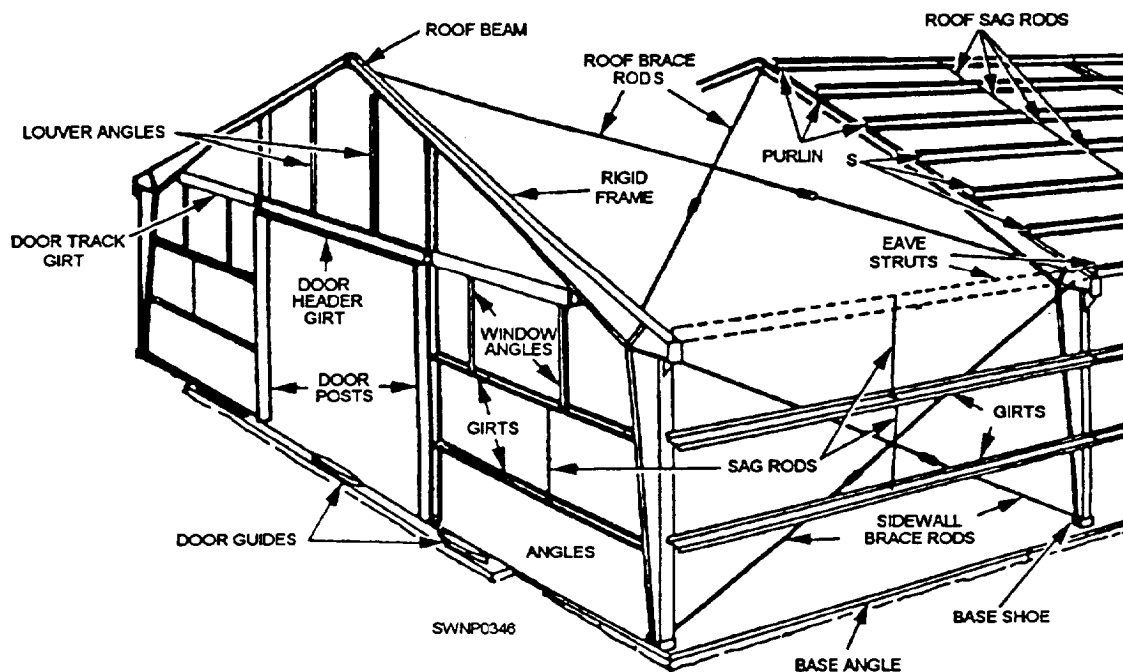


Figure 8-3.—Structural members of a pre-engineered building.

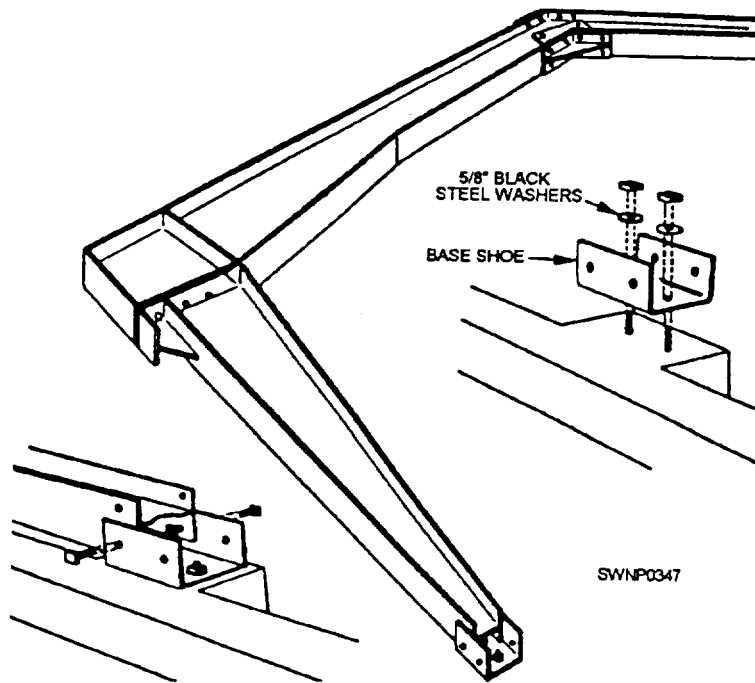


Figure 8-4.—Frame assembly.

127.124

frame when it is being raised, attach a bridle securely to each side of the frame below the splice connection and also to the ridge on the roof beam. Drop a driftpin in the frame, as shown in figure 8-5, to prevent the bridle from slipping up. Set up the gin pole with a block at the top. If a gin pole is not available, take three 2 by 6's, 20

feet long, from the longest shipping crate and nail them together.

Attach a tag line to the name, as shown in figure 8-5. Now, pull the end frame into the vertical position, using a crew of four or five people on the erection line. A tag person should have something to take a couple

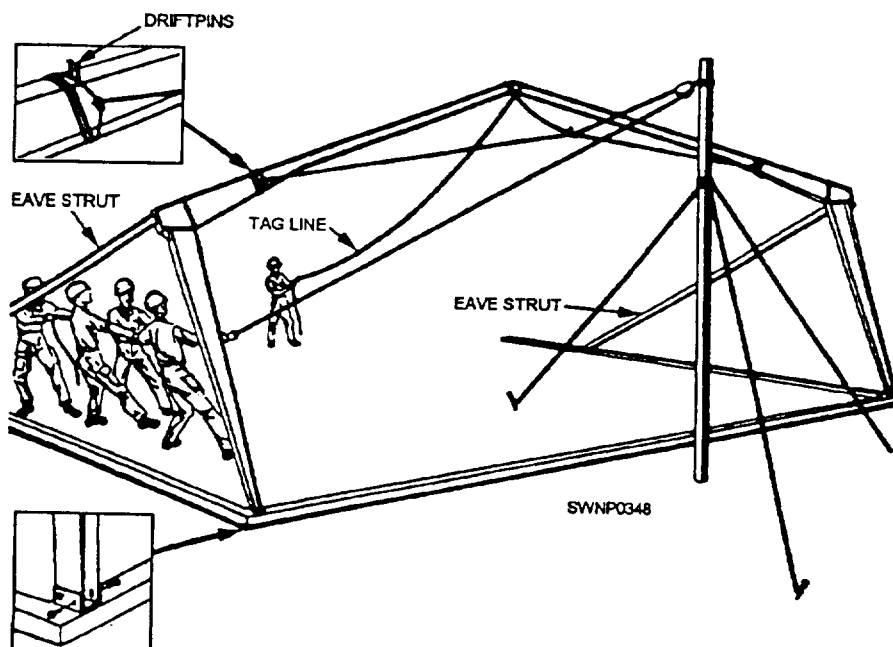


Figure 8-5.—Frame erection.

127.128

of turns around, such as the bumper of a truck. Then, if the frame should go beyond the vertical, the tag person would be able to keep it from falling.

To get the frame started from the ground, it should be lifted by several people and propped up as high as practical. Bolt an cave strut to each column, as shown in figure 8-5. The cave struts allow the frame to be propped at every stage of the lifting. After the frame is in a vertical position, install guy lines and props to it so it cannot move.

Now, raise the second frame in the same way, and hold it vertically in place by installing purlins, girts, and brace rods.

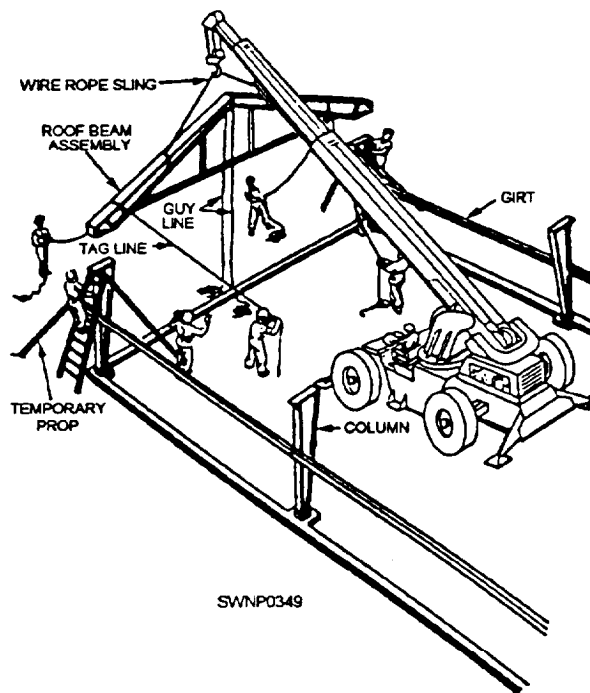
A crane or other suitable type of power equipment can be used to hoist the frames into place where such equipment is available. When power equipment is used, the suggested procedure to comply with is as follows:

1. Raise the columns and bolt them to the base shoes and then brace them in plain.
2. Install all sidewall girts to keep the columns as rigid as possible.
3. Bolt the roof beams together and install the gable posts and end-wall header.
4. Secure the guy lines, and tag lines to the roof beams, as shown in-figure 8-6. Attach a wire rope sling at approximately the center of each roof beam.
5. Hoist the roof beams into position on top of the columns and bolt them in place.
6. When the second rigid-frame section is secured in position, install all of the roof purlins, the gable angles, and the louver angles. Attach the gable clips to the purlins before raising into position.
7. Install the brace rods and align the first bay. THE FIRST BAY MUST BE ALIGNED BEFORE ERECTING ADDITIONAL BAYS.

### Brace Rods

Brace rods must be installed in the first bay erected (fig. 8-7). These rods are of paramount importance since they hold the frames in an upright position. THEY SHOULD NEVER BE OMITTED.

The diagonal brace rods are attached to the frames in the roof and sidewall through the slotted holes provided. Use a half-round brace rod washer and a flat steel washer under the nuts at each end of the rods.



127.129

Figure 8-6.—Using power equipment.

With the rods installed, plumb each frame column with the carpenter's spirit level.

Check the distance diagonally from the upper corner of one frame to the lower corner of the adjacent frame. When this distance is the same for each rod, the columns will be plumb. After the sidewall rods are installed, install the roof rods. The length of the roof rods can be adjusted by tightening or loosening the turnbuckle. When the two diagonal measurements are the same, the end bay will be square.

After the two frames have been plumbed and braced square with the diagonal rods (and the purlins, the girts, and the eave struts have been installed), the guy lines or props can be removed and the remaining frames of the building can be erected. To raise the next frame, attach blocks to the last frame raised.

Do not omit the diagonal brace rods that are required in the last bay of the building.

Be sure and bolt the girts, the purlins, and the cave struts to the inside holes of the end frames.

Install the cave struts, the girts, and the purlins in each bay as soon as a frame is erected.

Exercise care to see that the diagonal brace rods are taut and do not project beyond the flanges of the end frame to interfere with end-wall sheeting.

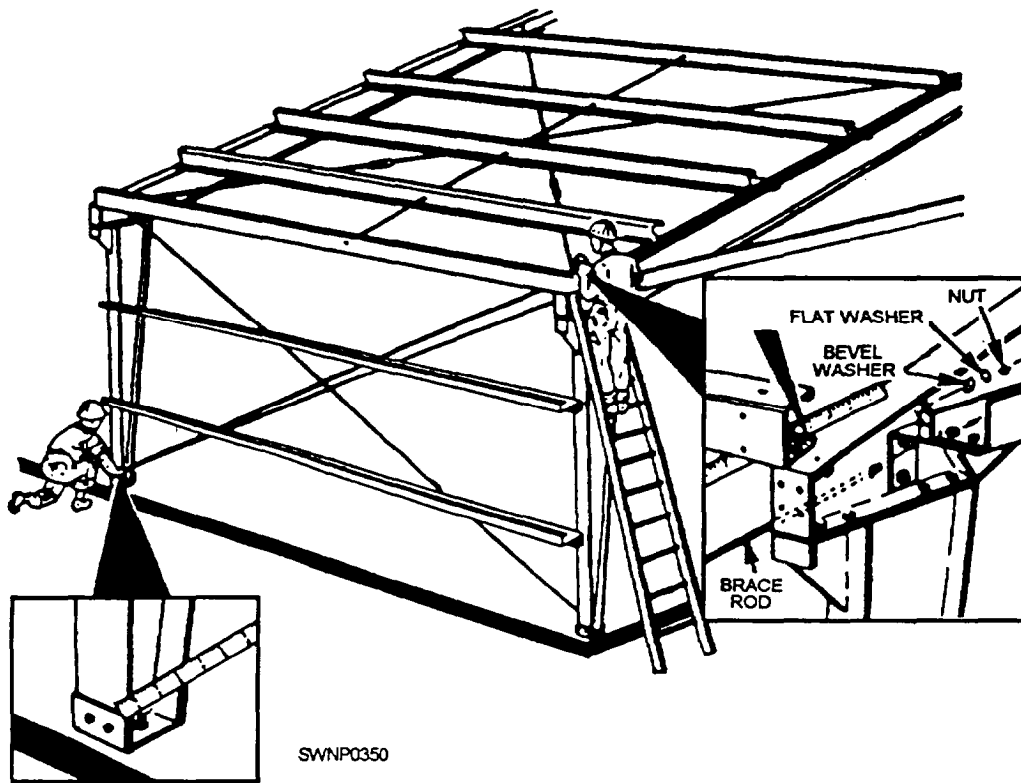


Figure 8-7.—Braoe rods.

127.130

## Sag Rods

Sag rods are used to hold the purlins and the girts in a straight line. First, install the sag rods that connect the two purlins at the ridge of the building. Each rod must be attached from the top hole of one purlin through the bottom hole of the adjacent purlin. Use two nuts at each end of the sag rods—one on each side of each purlin. Adjust the nuts on these rods, so the purlins are held straight and rigid.

Next, install the sag rods between the purlins below the ridge with the rod attached from the top hole of the upper purlin through the bottom hole of the lower purlin. Use two nuts on each end—one on each side of each purlin. Follow the same procedure with the sidewall sag rods.

Remember that the roof purlins should show a straight line from end to end of the building. Do NOT tighten the sag rods so much that the purlins are twisted out of shape.

## Brace Angles and Base Angles

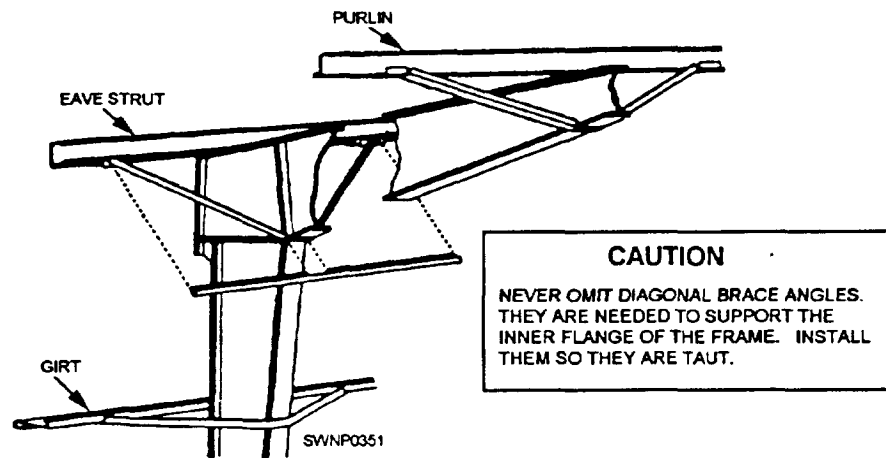
After two or more bays have been erected, part of the erection crew can be assigned to install the diagonal brace angles.

To install the brace angles, lay the notched portion against the frame flange and bend it into position (fig. 8-8). Diagonal brace angles are needed to support the inner flange of the frame. Be sure to install them so that they are taut.

While some members of the crew are installing brace angles, other members can be installing base angles. When assigned this duty, first, sweep off the top of the concrete foundation, so the base angles will set down evenly. Bolt the base angles in place with a flat steel washer under the nut. Leave the nuts loose to permit later adjustments after the wall sheeting has been applied.

## End-Wall Framing/Doors/Windows

Refer to the manufacturers' specifications for proper assembly and installation procedures for end-wall framing, doors (both sliding and roll-up), and



127.131

Figure 8-8.—Diagonal brace angles

windows, as these procedures will vary with available building options.

### Sheeting

Sheeting, both sidewall and roof, must always be started at the end of the building toward which the prevailing winds blow. This action will ensure that the exterior joint in the side laps is away from the blowing of the prevailing winds. When installing roof sheeting, always use a generous amount of mastic on the upper side of all roof sheets just before moving them to the roof. Turn the sheet over and put a bead of mastic on the lip of one side of the corrugation and along one end (near the end but never more than one 1 inch from the end). Be sure to apply a horizontal bead of mastic between all sheets in the end laps, **BELOW THE LAP HOLES**. The roof sheets must be dry when mastic is applied. Mastic is extremely important, and care should be exercised whenever applying it to ensure a watertight seal. Apply generous beads, especially at the corners of the sheets. Finally, the ridge cap will be installed ensuring proper watershed. As previous] y stated, the information in this manual is general information common to pre-engineered buildings.

### Building Insulation

The pre-engineered building can be insulated by any of several methods. A blanket type of insulation, in 2-foot-wide strips, to match the width of the roof and wall sheets can be installed between the sheets and structural at the same time the sheeting is installed. Or, a hardboard insulation can be applied directly to the inside surface of the structural, attaching it by

helix nails or by sheet-metal screws in holes prepared by drilling of the structural. Or, a wood framing can be prepared, attached to the structural, and a hardboard insulation is nailed to the wood.

### Buildings Set Side by Side “In Multiples”

Pre-engineered buildings can easily be set upside by side to increase the working area under one roof. When this is done, the adjacent rigid frames should be bolted back to back with a channel spacer at each girt location (fig. 8-9).

The cave struts are moved up the roof beam to the second set of 11/16-inch-diameter holes to provide a gutter. This arrangement provides a space between cave struts of 13 1/2 inches. A field-fabricated gutter can be installed.

Flat, unpainted galvanized steel of 24-to 26-gauge material should be used for the gutter. A depth of 6 1/4 inches is desirable with the downspouts located as required. Gutter ends should be lapped at least 6 inches and should be braze-welded for watertightness. Note that wall sheets can be used to form a gutter if the outside corrugations are flattened and all of the end laps are braze-welded.

Roof sheets must be cut shorter where they overhang the gutter. The corrugations can be closed with the continuous rubber closure with mastic applied to the top and bottom surfaces of the closure. An alternate method is to flatten the corrugations at the gutter and seal them with a glass fabric stripping set in plastic.

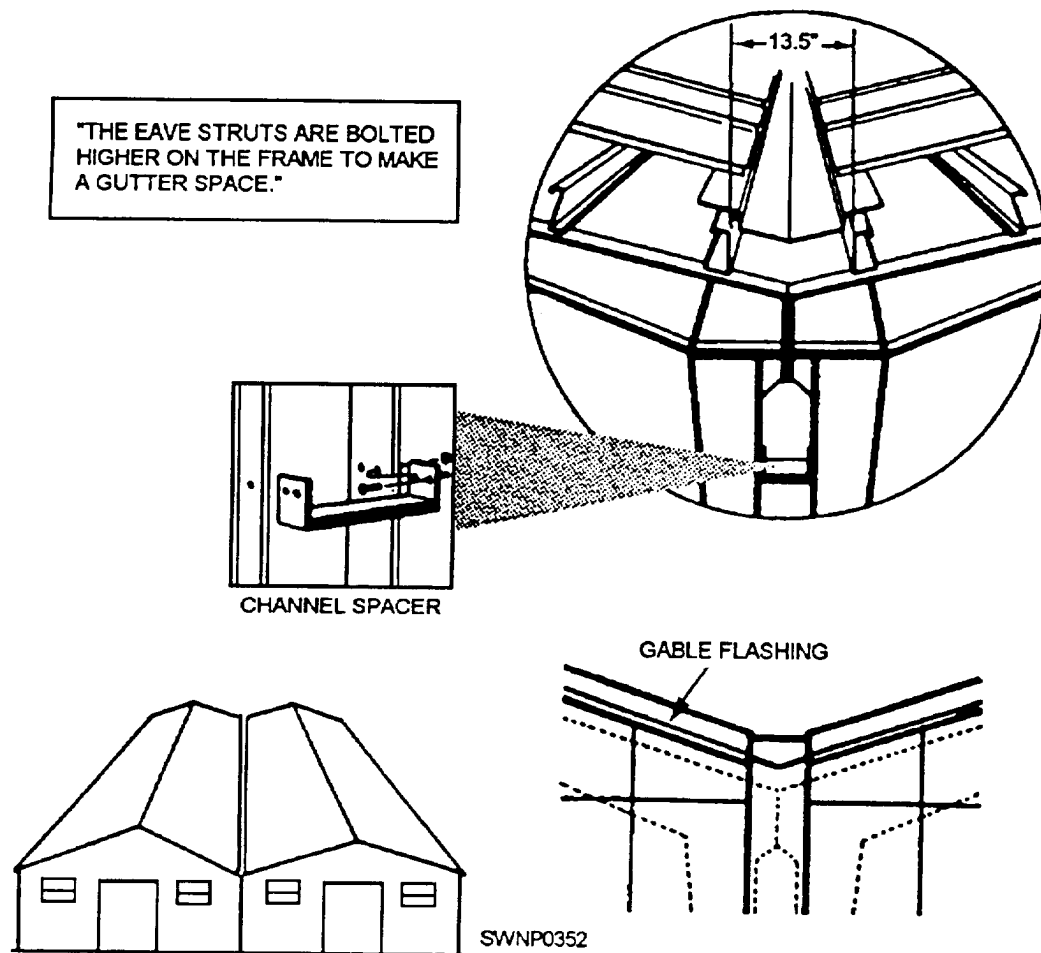


Figure 8-9.—Buildings side by side.

127.146

## DISASSEMBLY PROCEDURES

Disassembly of the pre-engineered building should not be difficult once you are familiar with the erection procedures. In disassembling a building, be sure and clearly mark or number all of the parts. Then you will know where the parts go when reassembling the building. The main steps of the disassembly procedures are as follows:

1. Remove the sheeting.
2. Remove the windows, the door leaves, and the end wall.
3. Remove the diagonal brace angles and the sag rods.
4. Remove the braces, the girts, and the purlins.
5. Let down the frames.

## K-SPAN BUILDINGS

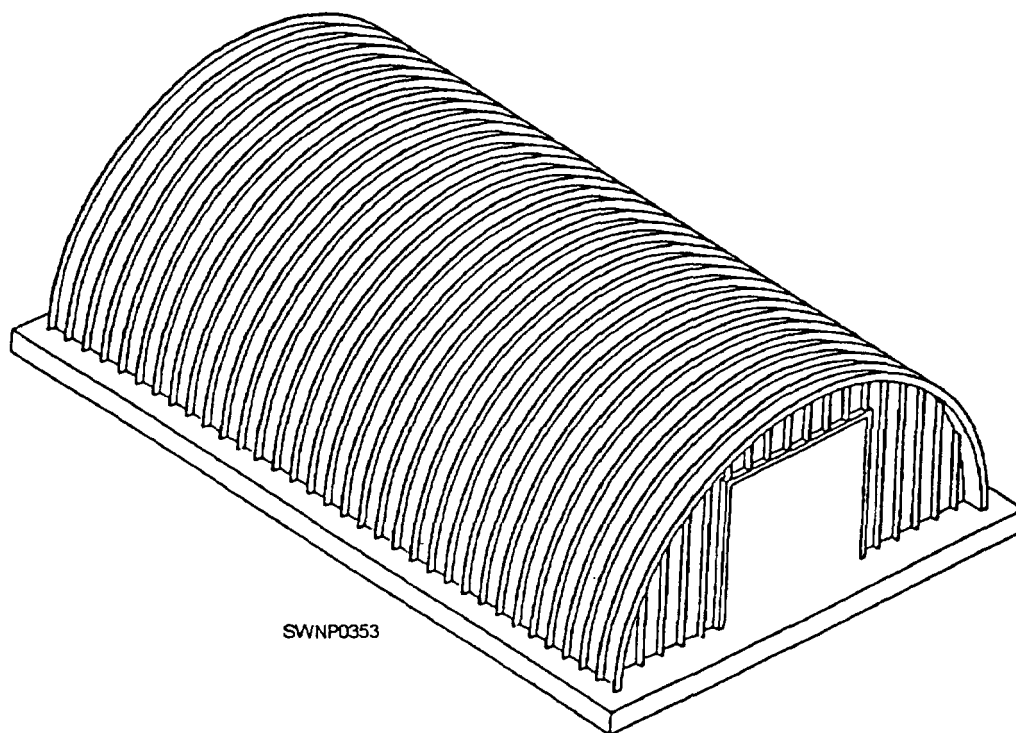
K-span buildings (fig. 8-10) are a new form of construction within the Seabee community. The intended uses of these buildings are as flexible as the pre-engineered buildings discussed earlier.

### ABM 120 SYSTEM

The K-span building system consists of a self-contained, metal building manufacturing plant, known as the ABM 120 System/Automatic Building Machine 120. This machine is mounted on a trailer, forming a type of "mobile factory" (fig. 8-11) that is easily towed to even the remotest construction sites. An important aspect of this machine is that it can be transported by air anywhere in the world easily. In fact, the ABM System has been certified for air transport by the U.S. Air Force in C-130, C-141, and C-5 aircraft.

Once the machine is delivered on site, it can be set up in minutes and turn coils of steel into structural





**Figure 8-10.—Typical K-span building.**

strength arched panels. The panels are then machine seamed together to form an economical and watertight steel structure.

The final shape and strength of the materials used cancels the need for columns, beams, or any other type of interior support. All of the panel-to-panel connections are joined using an electric automatic seaming machine. Because of this, there are no nuts, bolts, or any other type of fastener to slow down construction or create leaks.

Once delivered to the jobsite, the “on-site” manufacturing abilities of the machine give the ABM operator complete control of fabrication as well as the quality of the building. Training key personnel in the operation of all related K-span equipment is essential. These crew members, once trained, can instruct other members of the crew in the safe fabrication and erection of a K-span. The following section gives you some, but not all, of the key elements associated with K-span construction. As with all equipment, always refer to the manufacturers’ manuals.

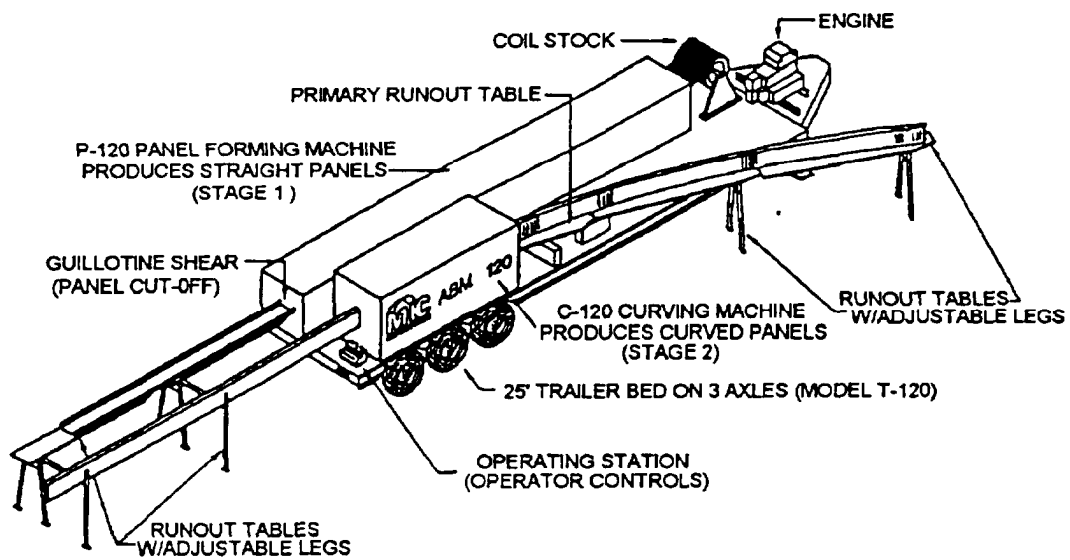
### **Operating Instructions**

The main component of the K-span system is the trailer-mounted building machine (fig. 8-12). This

figure shows the main components of the trailer and the general operating instructions. The primary position is the operator’s station at the rear of the trailer (fig. 8-13). The crew member, selected for this position, must have a thorough understanding of the machine operations and the manuals. From that position, the operator controls all of the elements required to form the panels. First, the operator must run the coil stock through the machine to form the panel shape. Next, it is cut off at the correct length. This length is the required length for one arched panel to run continuously from one footer to the other. Last, after the panel is cut to length, it is run back through the machine to give it the correct arch. The operator must remain at the controls at all times. From the placement of the trailer on site to the completion of the curved panel, attention to detail is paramount as with all of the aspects of construction.

As you operate the panel, you will be adjusting the various machine-operating components. Adjustments for the thickness, the radius, and the curving machine **MUST** be made according to the manuals. Do not permit shortcuts in adjustments. Any variations in adjustments or disregard for the instructions found in the operating manuals will leave you with a pile of useless material or an inconsistent building.

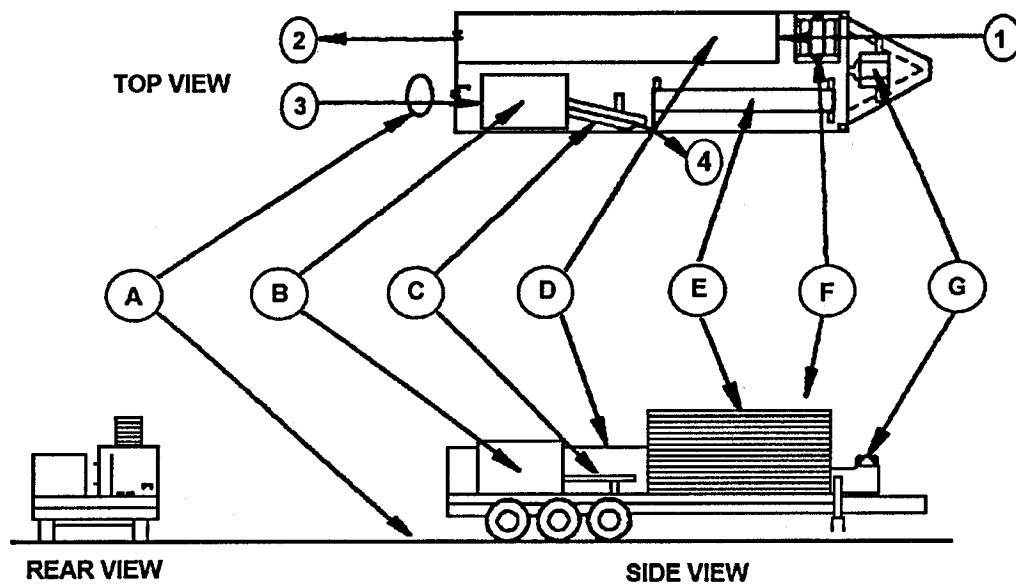
**MIC-120 ABM (K-SPAN)  
AUTOMATIC BUILDING MACHINE**



XXSW0354

Figure 8-11.—Automatic Building Machine 120.

Copyright ©1993 by MIC Industries, Inc.



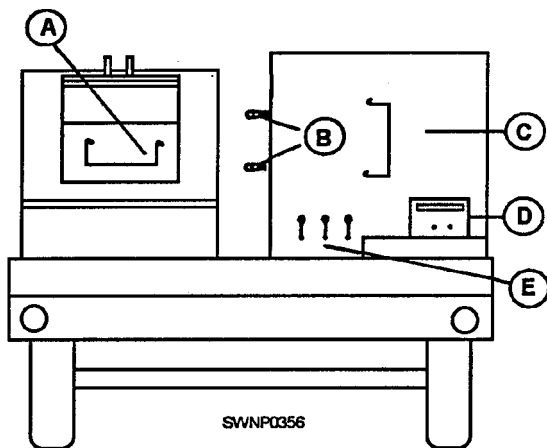
SWNP0355

- A. OPERATOR'S STATION  
 B. PANEL CURVING MACHINE  
 C. PRIMARY CURVING RUN-OUT TABLE  
 D. STRAIGHT PANEL ROLL FORMING MACHINE  
 E. RUN-OUT TABLES IN TRANSPORTING RACK  
 F. COIL STOCK PAY-OUT REEL AND STAND  
 G. ENGINE/HYDRAULIC PUMP PRIMARY POWER UNIT

**GENERAL OPERATION (TOP VIEW)**

1. COIL STOCK ENTERS PANEL FORMING MACHINE
2. FORMED STRAIGHT PANEL
3. STRAIGHT PANEL ENTRY TO PANEL CURVING MACHINE
4. CURVED BUILDING PANEL

Figure 8-12.—Trailer-mounted machinery.



**OPERATOR'S STATION, AT REAR OF TRAILER:**

- A. STRAIGHT PANEL EXIT AND CUT-OFF  
 B. CURVING MACHINE RADIUS ADJUSTMENTS AND DIALS  
 C. STRAIGHT PANEL ENTRANCE TO CURVING MACHINE  
 D. ENGINE REMOTE CONTROL PANEL  
 E. HYDRAULIC CONTROLS

Figure 8-13.—Rear of K-span trailer.

**Machinery Placement**

Preplanning of the site layout is important to avoid setup problems. Uneven or sloped ground is not a

concern as long as the bed of the trailer aligns with the general lay of the existing surface conditions. Using figure 8-14 as a guide when placing the machinery, you should consider factors such as the following:

- Maneuvering room for the towing of the trailer, or leave it attached to the vehicle (as shown at A).
- The length of the unit is 27 feet 8 inches long by 7 feet 4 inches wide (B).
- Allow enough room for run-out stands to hold straight panels. Stands have a net length of 9 feet 6 inches each (C).
- Find point X: From the center of the curve, measure the distance equal to the radius in line with the front of the curved frame. From point X, scribe an arc equal to the radius. This arc will define the path of the curved panel. Add 10 feet for run-out stands and legs (D).
- Storage area required to store the coil stock and access for equipment to load onto the machine (E).

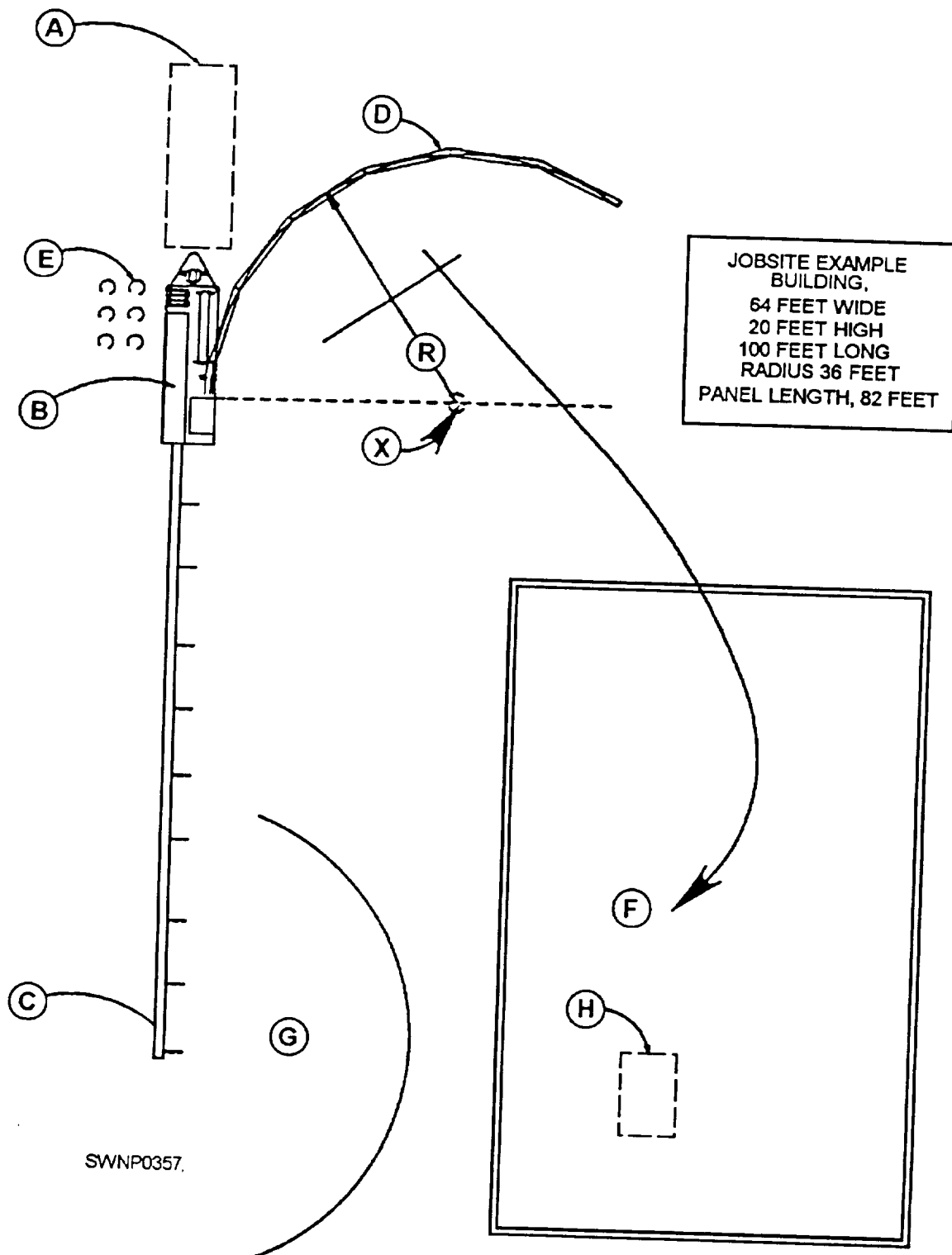


Figure 8-14.—Machinery placement calculations.

- Direction curved panels must be carried after being formed (F).
- Level area required to lay panels on the ground for seaming. Building will not be consistent if panels are not straight when seaming (G).
- Space required for crane operations (I-I).

## Foundations

The design of the foundation for a K-span building depends on the size of the building, the existing soil conditions, and the wind load. The foundations for the buildings are simple and easy to construct. With the even distribution of the load in a standard arch building, the size of the continuous strip footing is smaller and therefore more economical than foundations for more conventional buildings.

The concrete forms and accessories provided are sufficient to form the foundations for a building 100

feet long by 50 feet wide. When a different configuration is required, forms are available from the manufacturer.

The actual footing construction is based, as with all projects, on the plans and specifications. The location of the forms, the placement of the steel, and the psi (pounds per square inch) of the concrete are critical. The building panels are welded to the angle in the footer before the concrete is placed. Because of this operation, all of the aspects of the footer construction must be completely checked for alignment and squareness. Once concrete is placed, there is no way to correct errors.

As mentioned above, forms are provided for the foundation. Using table 8-1 as a guide, figure 8-15 gives you a simple foundation layout by parts designation. As noted in figure 8-15, the cross pipes are not provided in the kit. They must be ordered when the project is being planned and estimated.

Table 8-1.—Concrete Forms Included in Kit

DESCRIPTION (Each set of forms is sufficient to erect a building 100 feet long by 50 feet wide.)	PART NUMBER
Side form panels, 1' × 10', 12-gauge steel	F-1
Transition panels, 1' × 12", 12-gauge steel	F-2
Transition panels, 1' × 28", 12-gauge steel	F-3
End-wall caps, 1' × 15", 12-gauge steel	F-4
Sidewall caps, 1' × 19", 12-gauge steel	F-5
Filler form, 1' × 12', 12-gauge steel	F-6
Sidewall inside stop, 1' × 12", 12-gauge steel	F-7
End wall inside stop, 1' × 12", 12-gauge steel	F-8
Stakes, 1/4" diameter, bar steel	F-9
All-thread rod, 1/2-13 × 18"	F-10
Hex nuts, 1/2-13	F-11
Hex bolts, 1/8-16 × 1 1/2"	F-12
Hex nuts, 3/8-16	F-13
Flat washers, 1/8" SAE	F-14

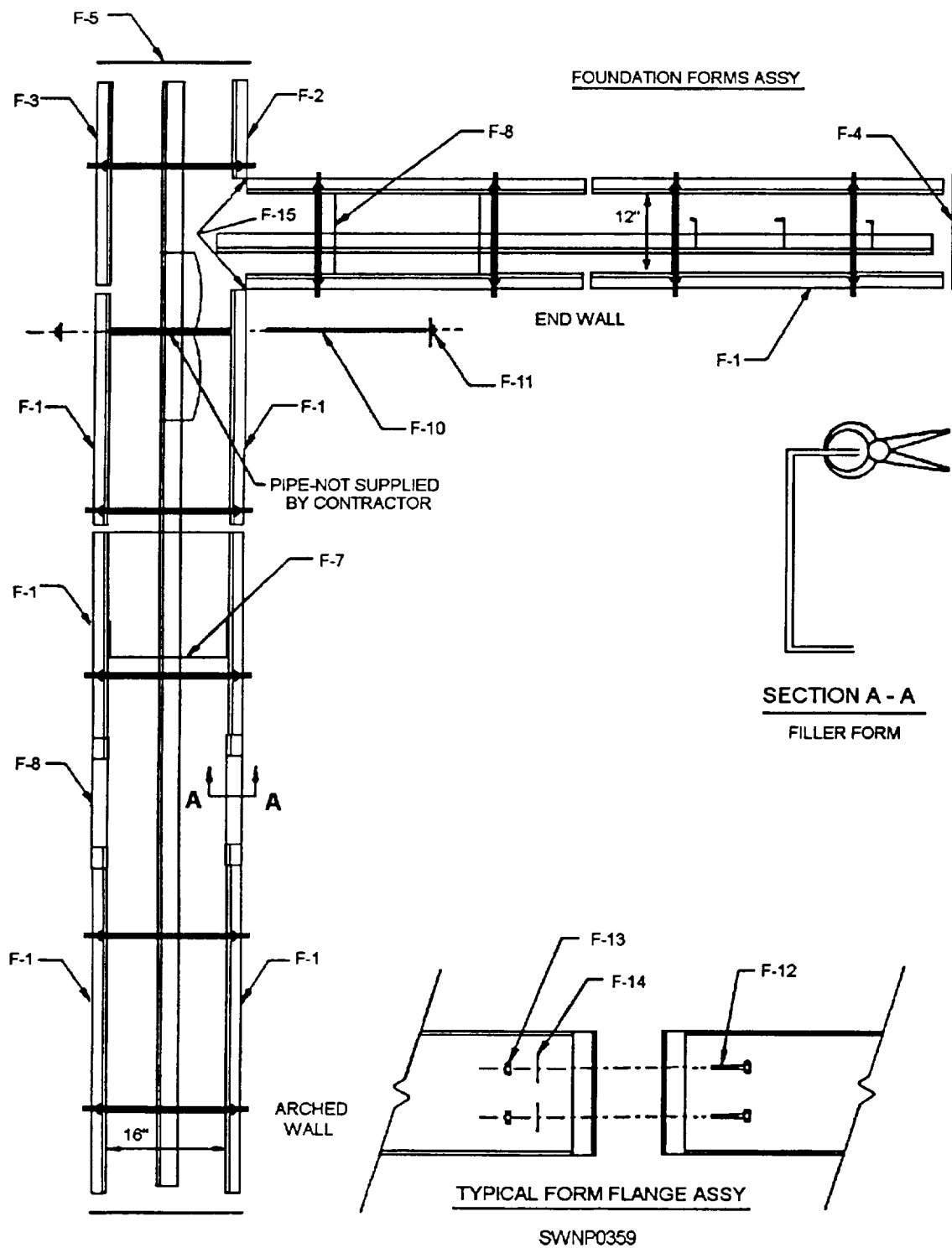


Figure 8-15.—Simple form assembly.

## BUILDING ERECTION

With the placement of the machinery and forming of the building panels in progress, your next considerations are the placement and the weight-lifting capabilities of the crane. Check the weight-lifting chart of the crane for its maximum weight capacity. This dictates the number of panels you can safely lift at the operating distance. As with all crane operations, attempting to lift more than the rated capacity can cause the crane to turn over.

Attaching the spreader bar (fig. 8-16) to the curved formed panels is a critical step; failure to clamp the panel tightly can cause the panels to slip and fail with potential harm to personnel and damage to the panel. With guide ropes attached (fig. 8-17) and personnel manning these ropes, lift the panels for placement. When lifting, lift only as high as necessary, position two men at each free end to guide them in place, and remind crew members to keep their feet from under the ends of the arches. Never attempt lifting any sets of panels in high winds.

Place the first set of panels on the attaching angle of the foundation, and position them so there will be room for the end-wall panels. After positioning the first set of panels, clamp them to the angle, plumb with guide ropes, and secure the ropes to previously anchored stakes. Detach the spreader bar and continue to place the panel sets. Seam each set to standing panels before detaching the spreader bar.

After about 15 panels (three sets) are in place, measure the building length at both ends (just above forms) and at the center of the arch. This measurement will seldom be exactly 1 foot per panel (usually slightly more), but should be equal for each panel. Adjust the ends to equal the center measure. Panels are flexible enough to adjust slightly. Check these measurements periodically during building construction. Because exact building lengths are difficult to predict, the end wall attaching angle on the finishing end of the building should not be put in place until all of the panels are set.

After arches are in place, set the longest end-wall panel in the form, plumb, and clamp it in place. Work from the longest panel outward and be careful to maintain plumb.

When all of the building panels are welded to the attaching angle (fig. 8-18) at 12 inches on center, you

are ready to place the concrete. When you are placing the concrete, remember it is extremely important that it be well-vibrated. This action may eliminate voids under all embedded items. As the concrete begins to set, slope the top exterior portion of the concrete cap about 5 inches (fig. 8-19) to allow water to drain away from the building. The elevation and type of the interior floor are not relevant as long as the finish of the interior floor is not higher than the top of the concrete cap.

The K-span building system is similar to other types of pre-engineered or prefabricated buildings in that windows, doors, and roll-up doors can be installed only when erection is completed. When insulation of the building is required, insulation boards (usually 4 by 8 feet) maybe of any semirigid material that can be bent to match the radius of the building. The insulation is installed using clips, as shown in figure 8-20.

When the integrity of the end-wall panels is continuous from ground to roof line, the end walls become self-supporting. The installation of windows (fig. 8-21) and aluminum doors (fig. 8-22) presents no problem because the integrity of the wall system is not interrupted. The installation of the overhead door (fig. 8-23) does present a problem in that it does interrupt the integrity of the wall system. This situation is quickly overcome by the easily installed and adjustable (height and width) doorframe package that supports both the door and end wall. This doorframe package is offered by the manufacturer.

Shown in figure 8-24 are the fundamental steps in constructing a K-span from start to finish.

### ABM 240 SYSTEM

There is another type of K-span building, actually referred to as a Super Span by the manufacturer, the ABM 240. Actual construction of the ABM 240 is the same as the ABM 120 (K-span). It can use heavier coil stock and is a larger version. Figure 8-25 is given to show the differences between the two.

Keep in mind that the information provided in this section on the K-span building is basic. During the actual construction of this building, you must consult the manufacturer's complete set of manuals.

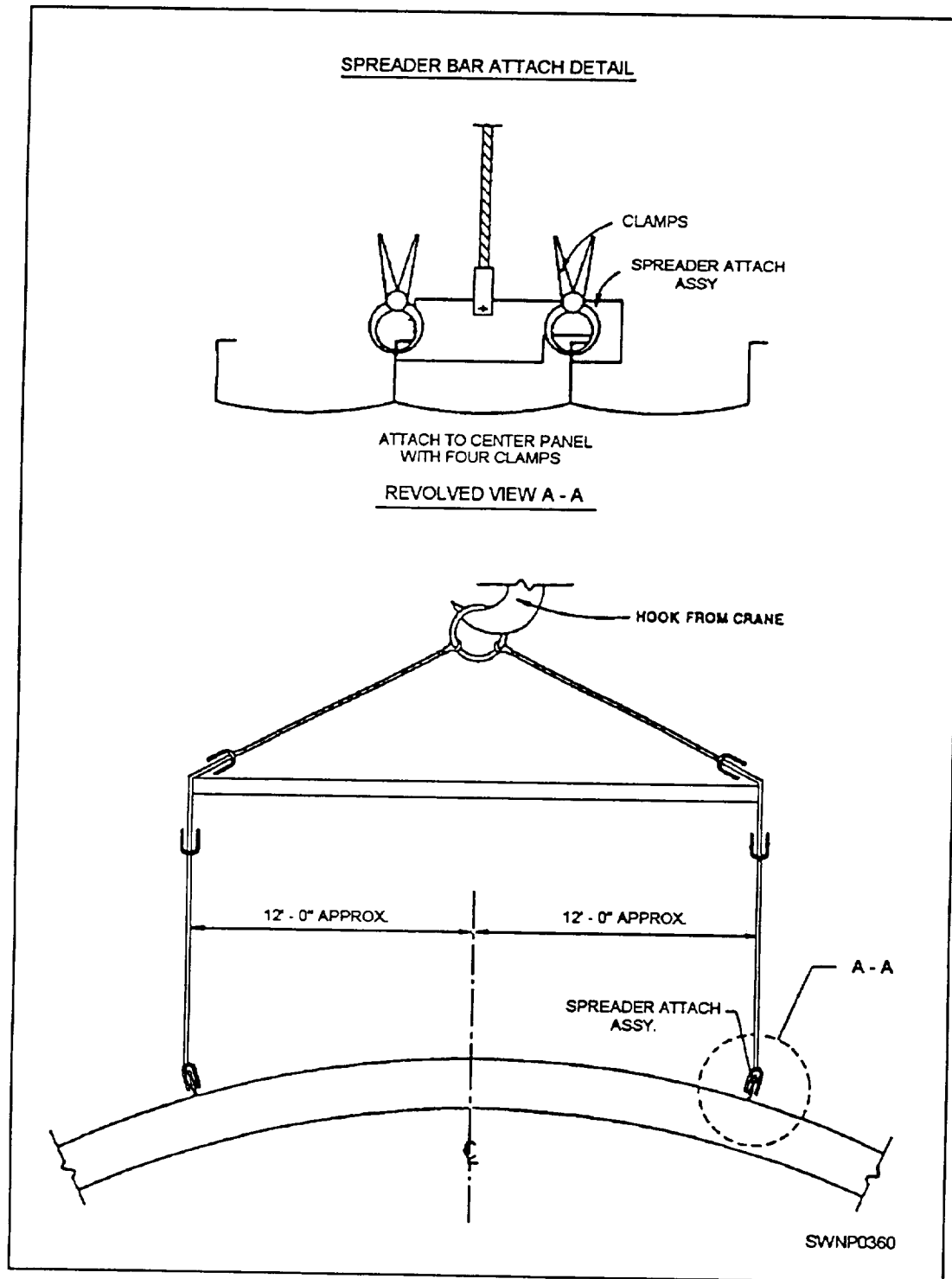


Figure 8-16.—Spreader bar attachment.



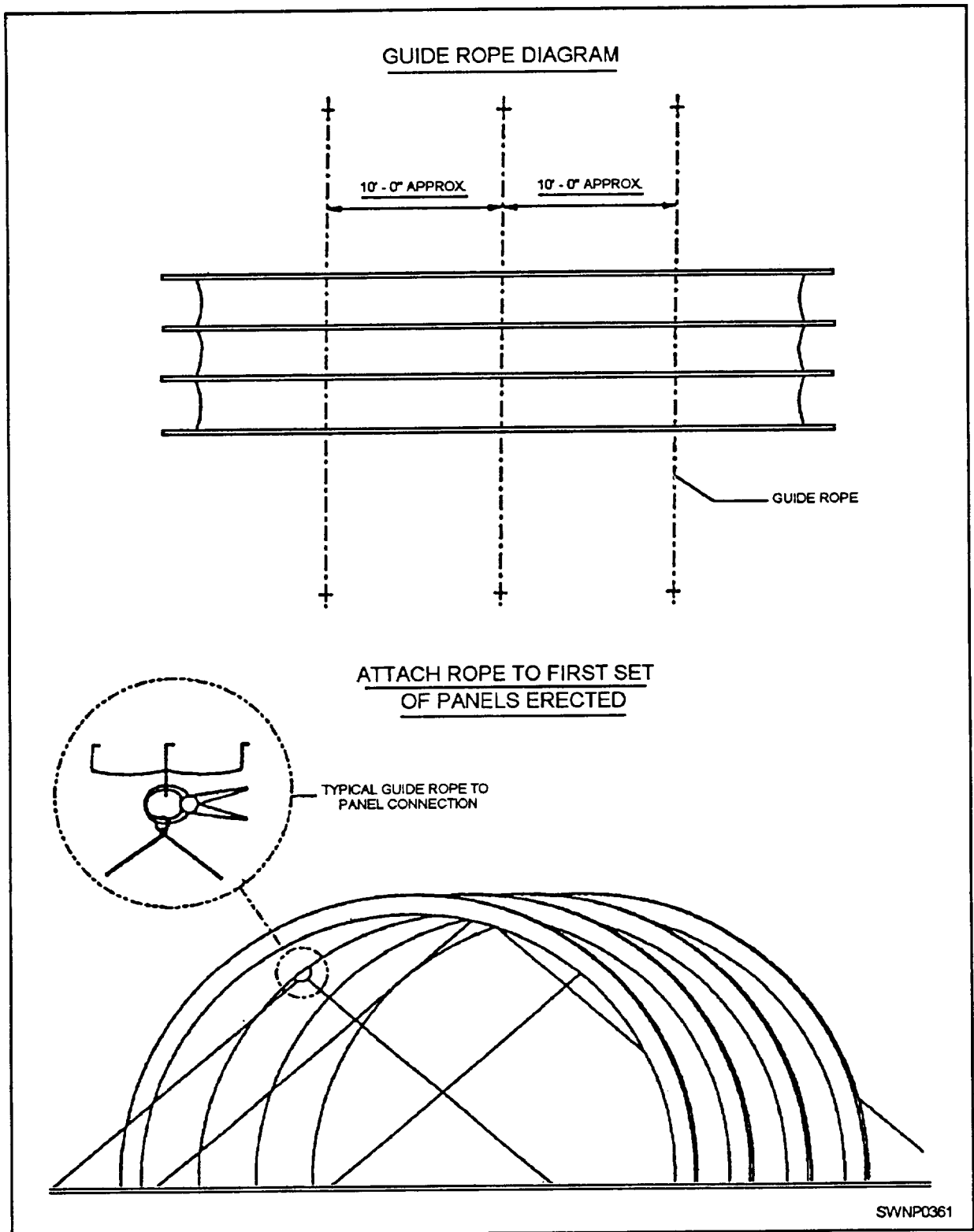


Figure 8-17.—Guide rope diagram.

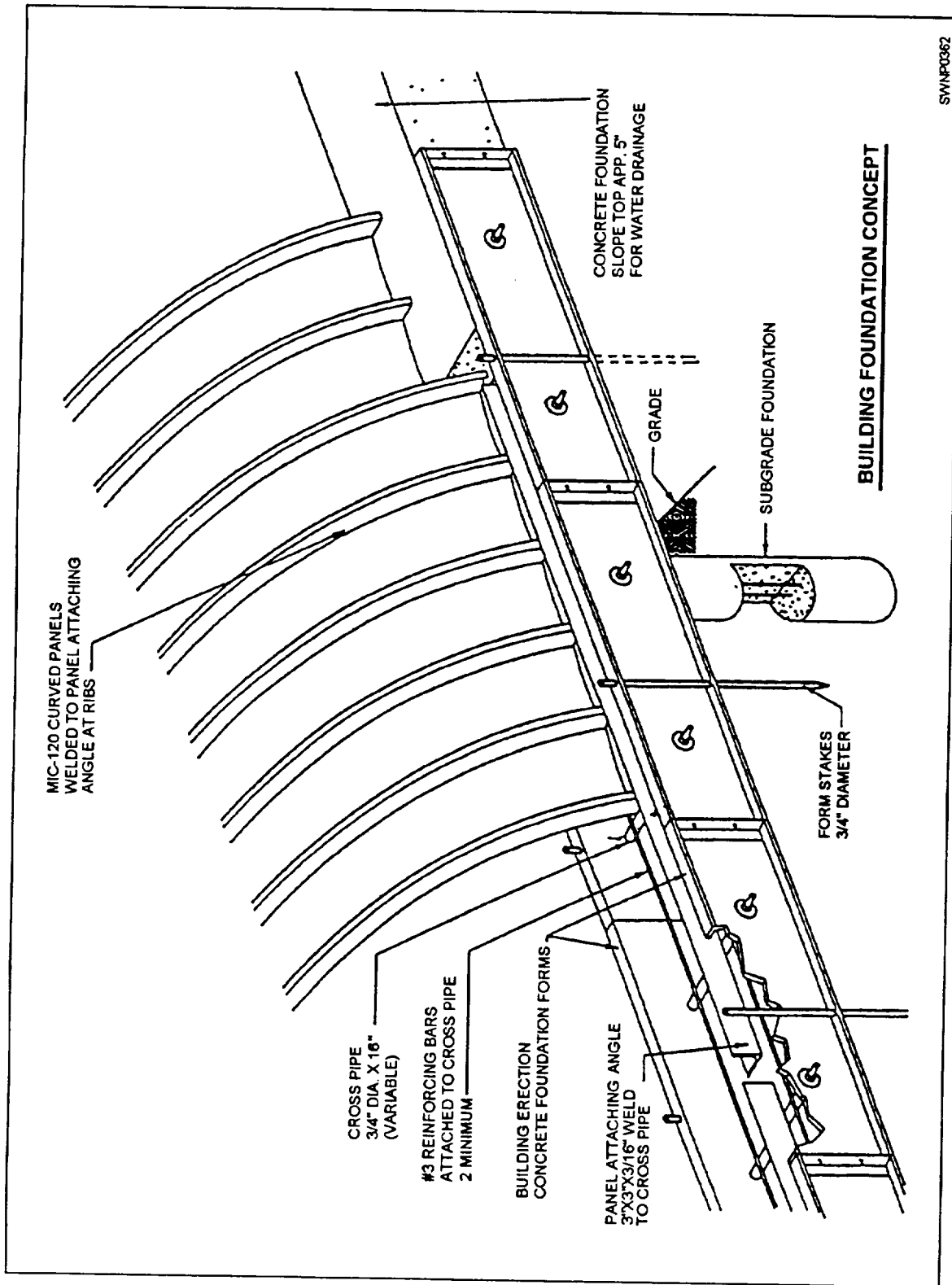


Figure 8-18.—Building foundation concept.

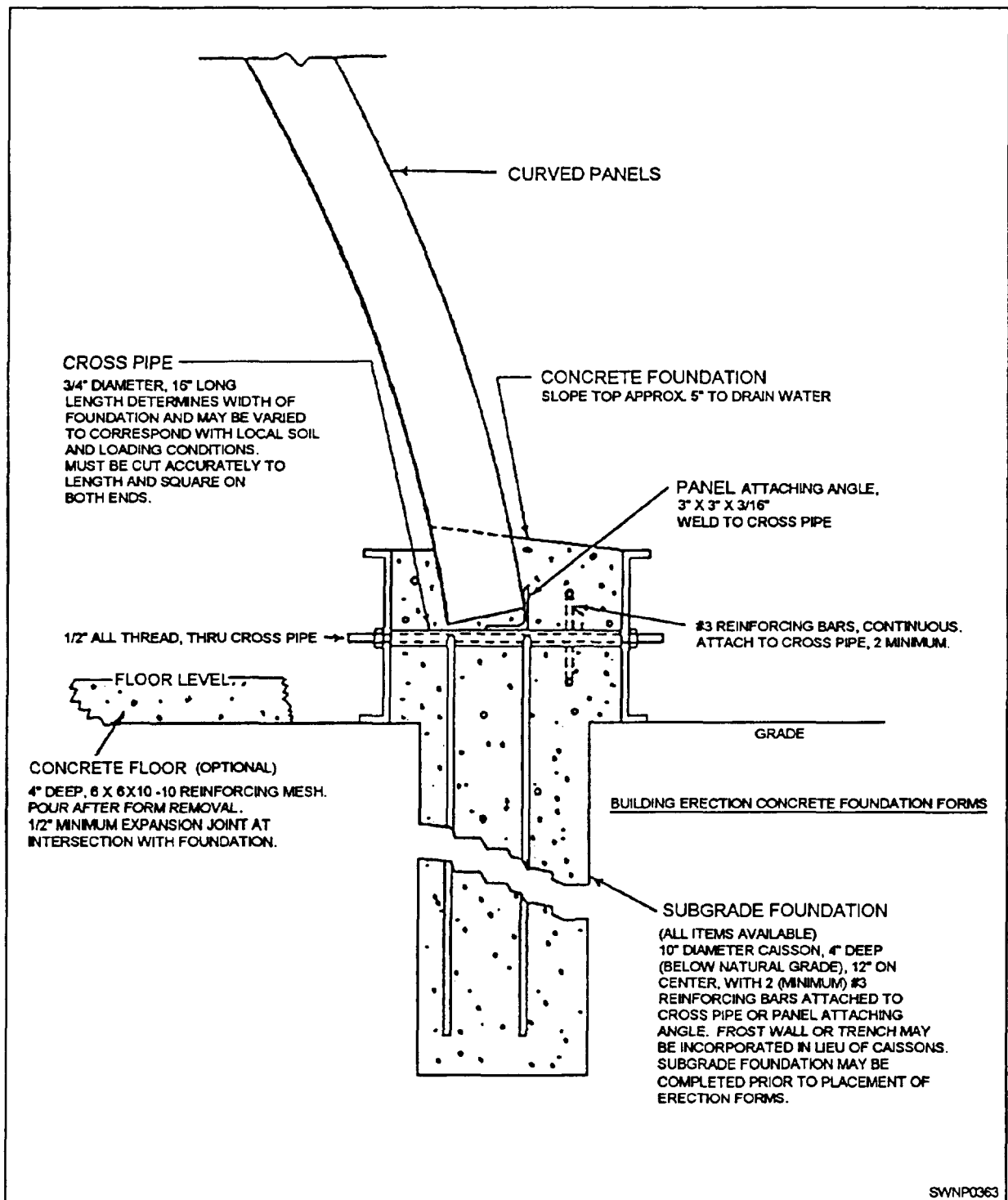


Figure 8-19.—Concrete foundation.

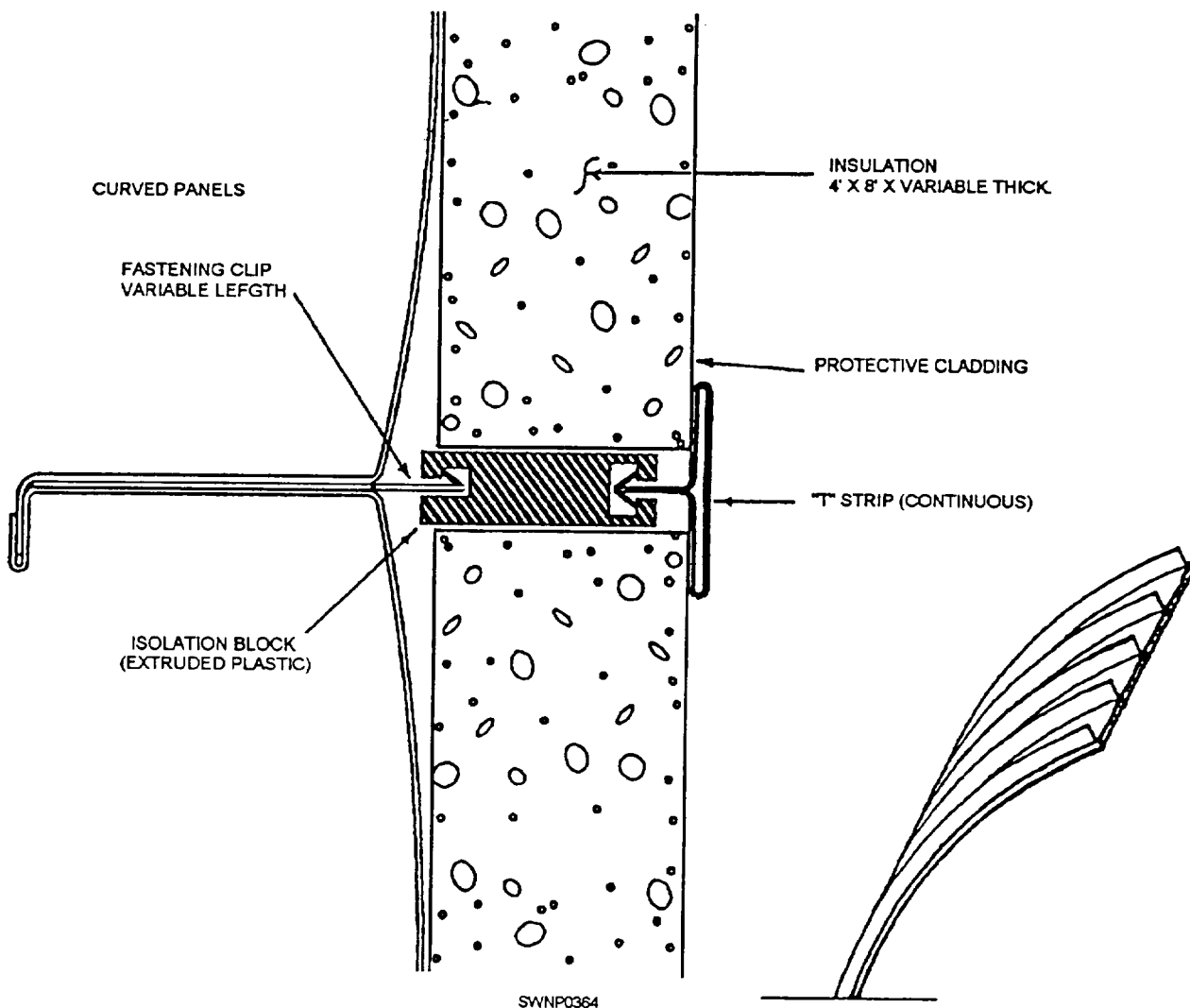


Figure 8-20.—Insulation.

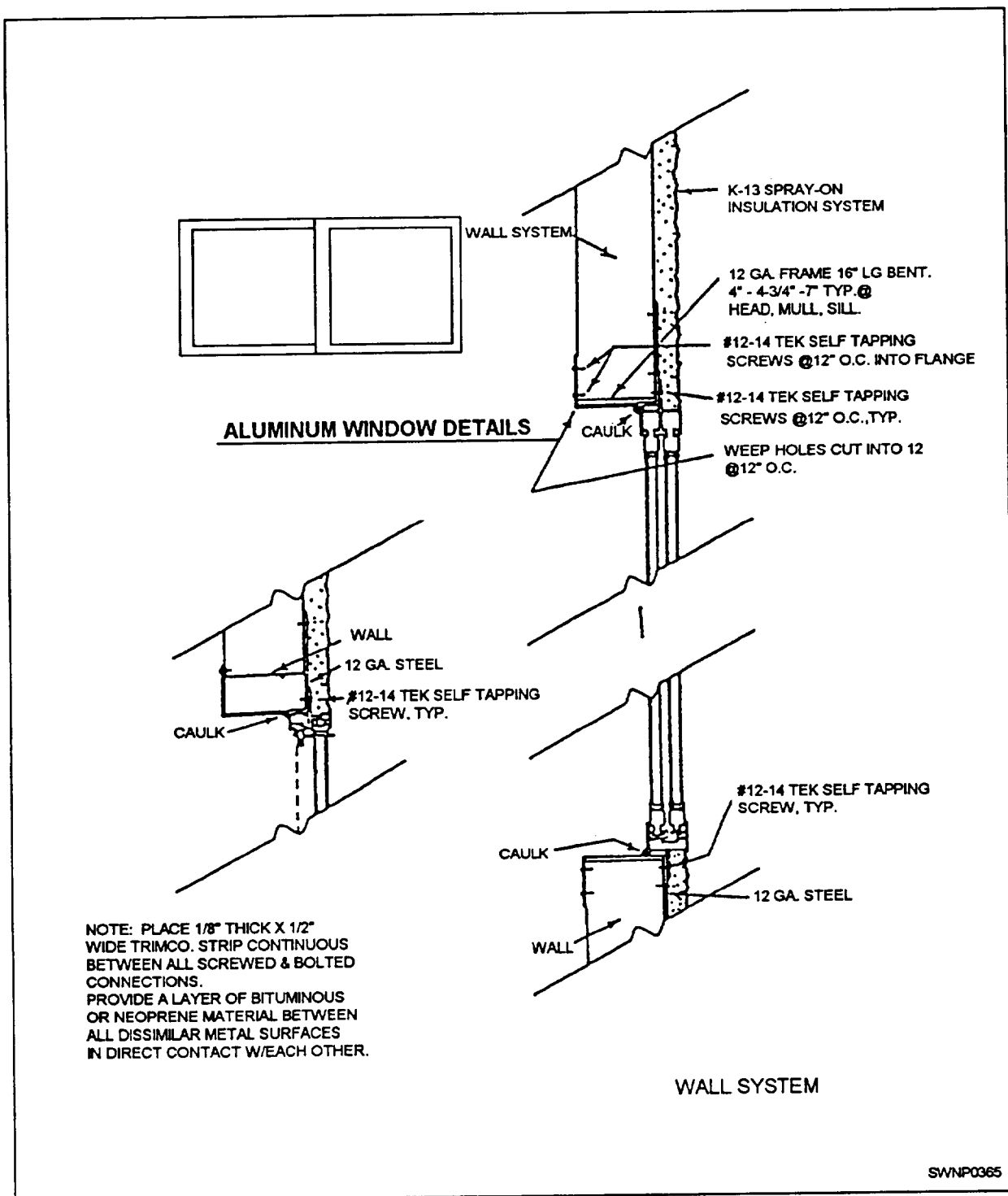
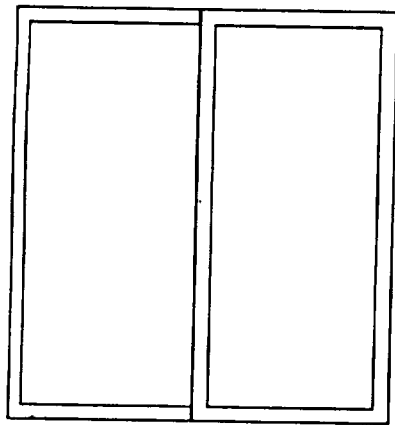
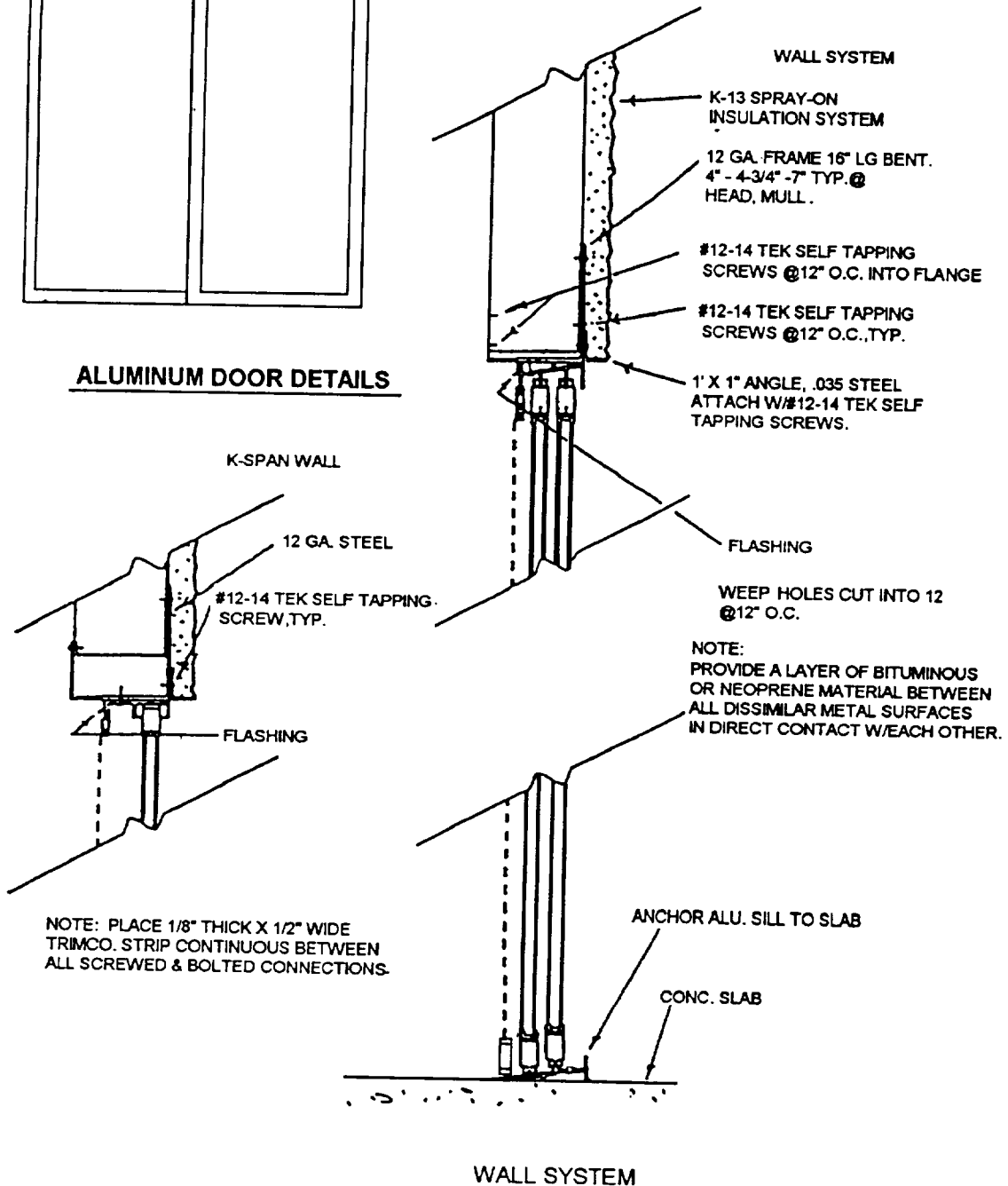


Figure 8-21.—Aluminum window installation.



### ALUMINUM DOOR DETAILS



SWNP0366

Figure 8-22.—Aluminum door installation.

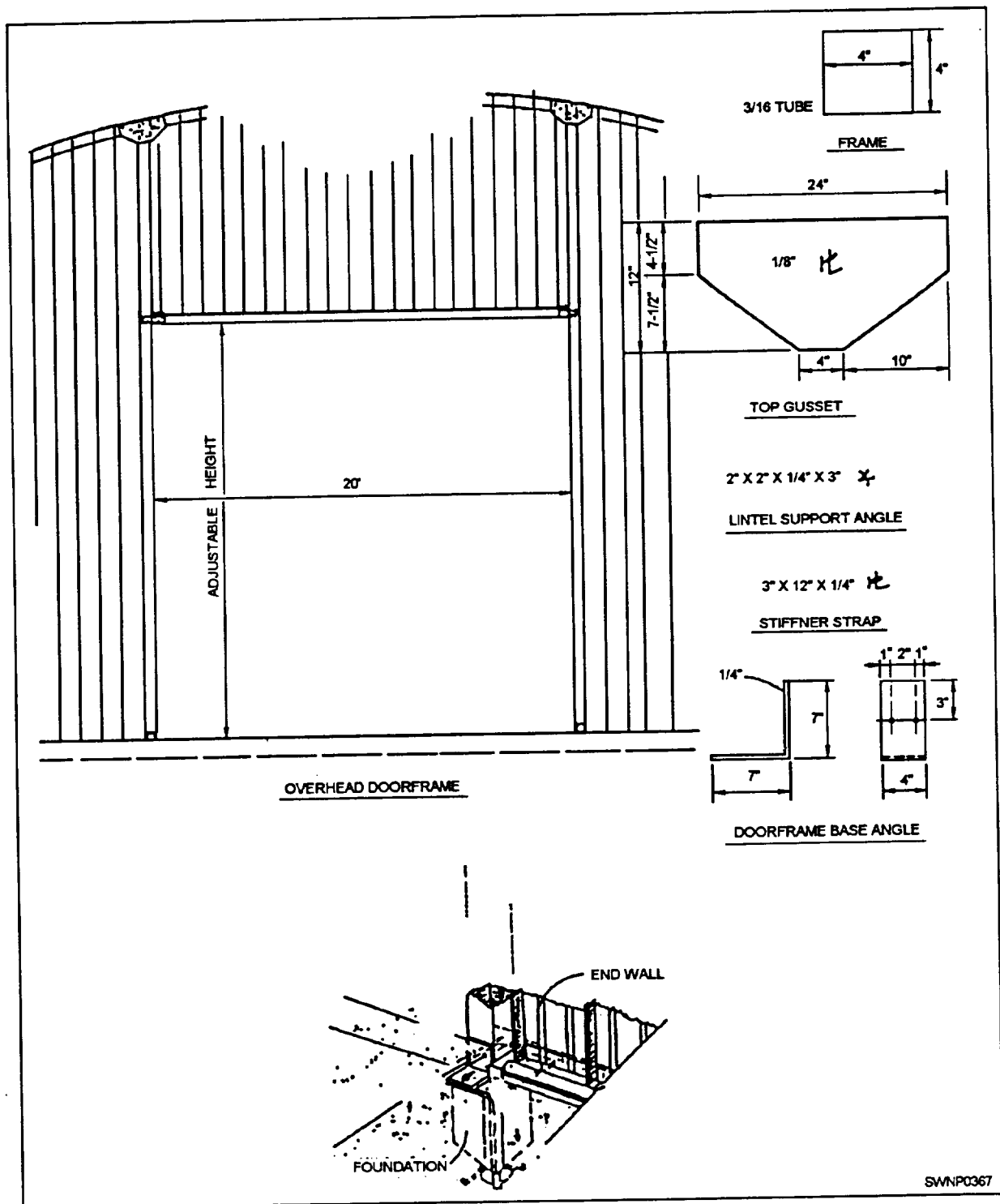
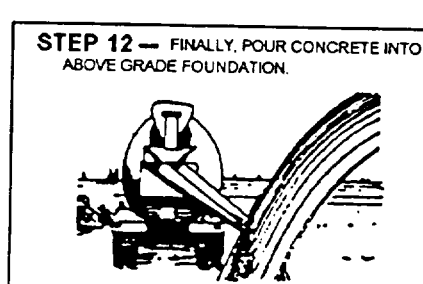
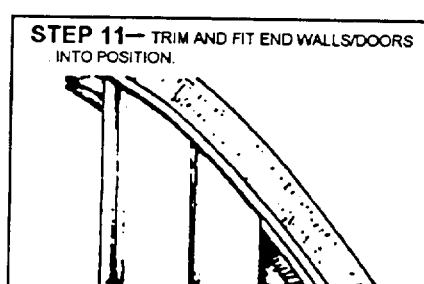
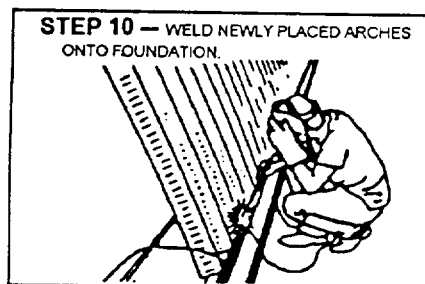
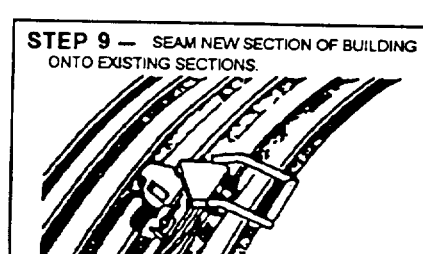
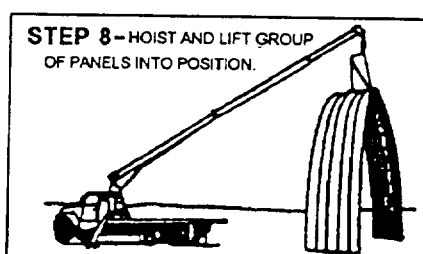
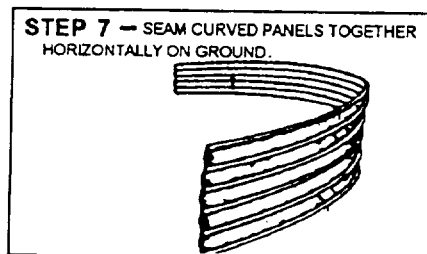
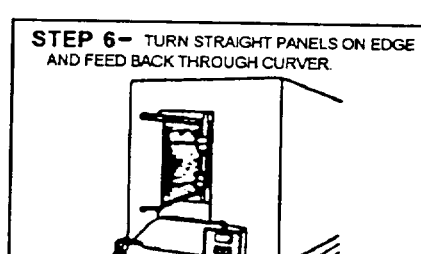
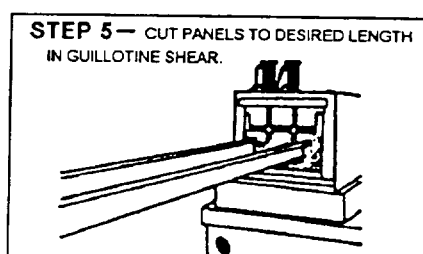
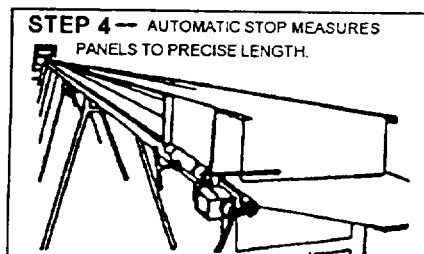
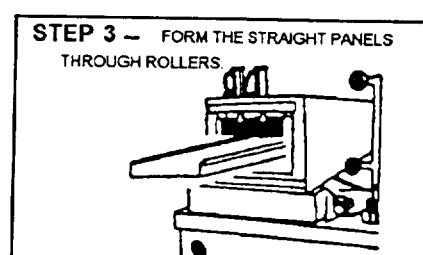
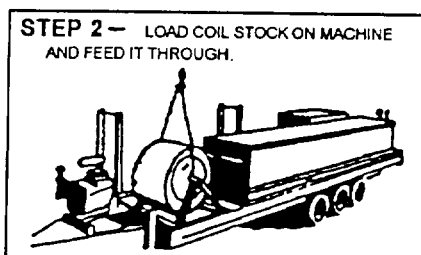
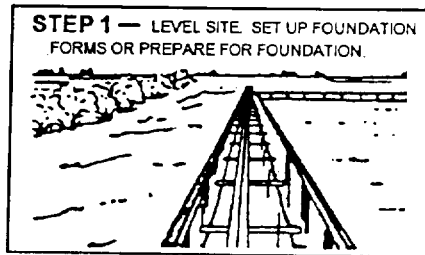


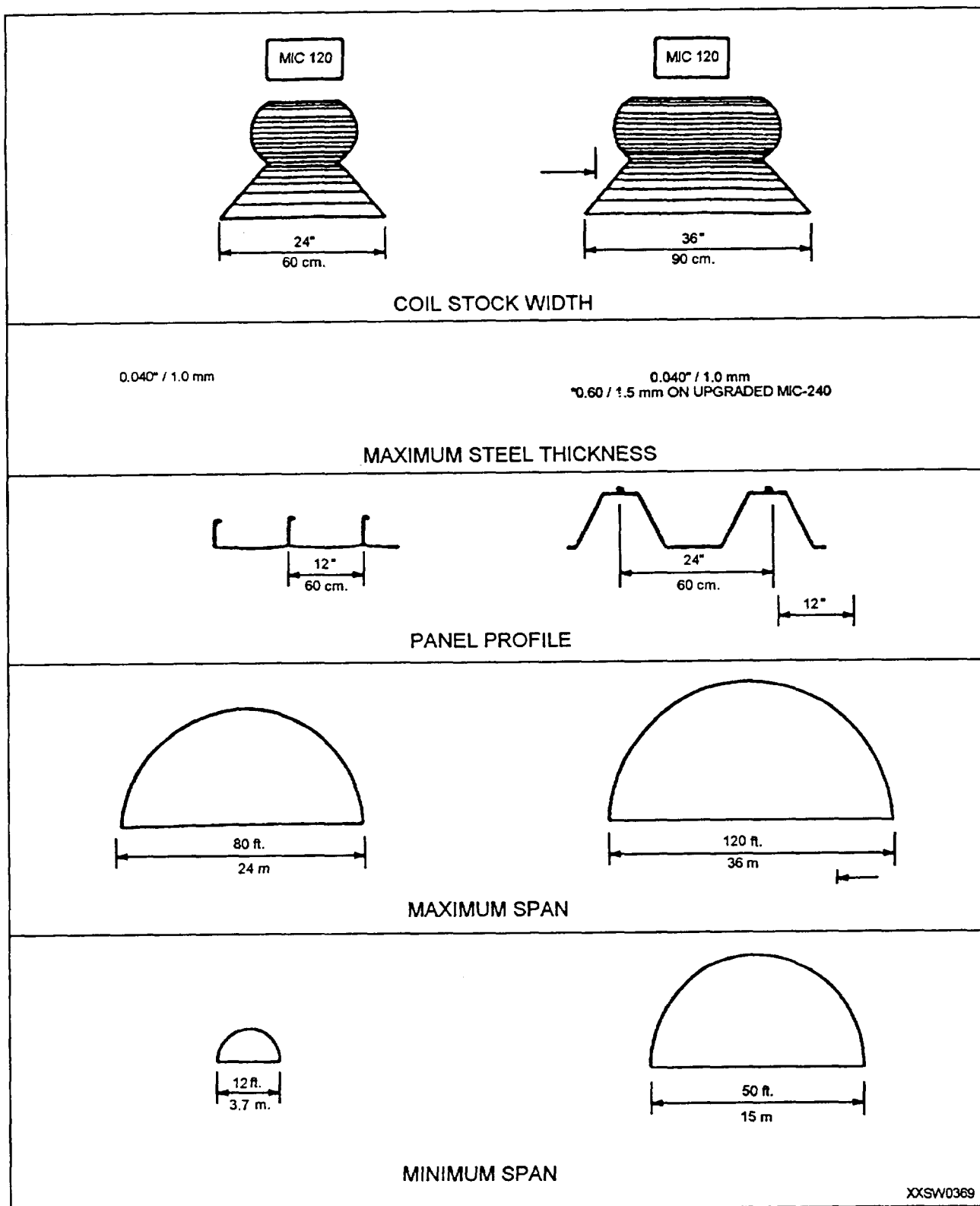
Figure 8-23.—Overhead doorframe.



XXSW0368

Figure 8-24.—Steps in K-span construction.





XXSW0369

Figure 8-25.—ABM System 120 and 240 comparison chart.

## STEEL TOWERS

Airfield observation towers, harbor shipping control towers, and radio towers are all erected by Steelworkers. These towers are manufactured and packaged according to military specifications. They are shipped with all parts and with plans and specifications.

The framework of the tower is made up of fabricated structural shapes that are bolted together. Anchor angles with baseplates are furnished for setting in the concrete foundation, as shown in figure 8-26. In most cases, the foundation will be built by the Builders. The manufacturer also furnishes square head bolts, lock washers, and nuts. Spud wrenches and driftpins are supplied for each size of bolt. Field bolts and shipping lists are prepared and packaged with each shipment of a tower.

The tower members are bundled in the most compact manner possible to keep shipping space to a minimum. Erection identification marks and stock list

numbers are painted on all of the pieces. All of the nuts, the bolts, and the washers are boxed and identified by painted marks.

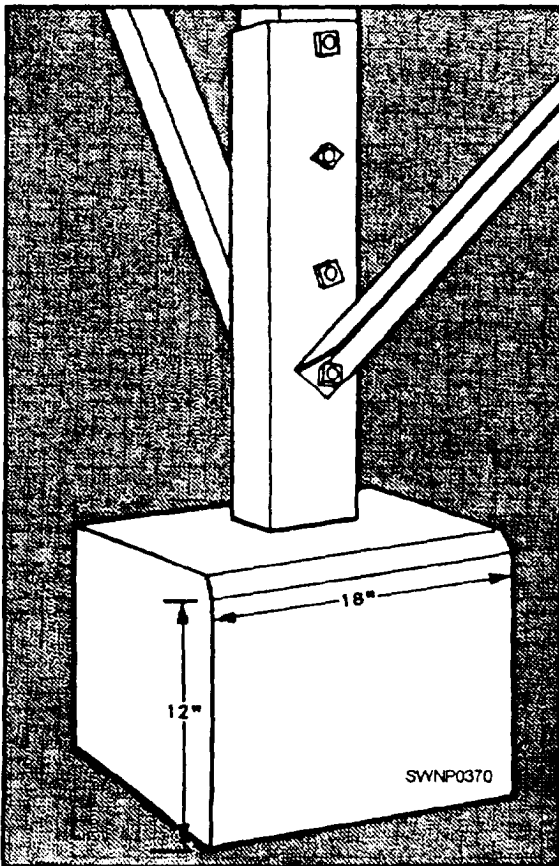
A check must be made of all of the parts and packages received in a tower shipment. Check them against the shipping list to be sure that no boxes or bundles have been lost, stolen, or misplaced. Also, check to see that none have been damaged. When all are accounted for, sort the materials. The drawings tell you what is needed for each section. It is smart planning to lay out all of the materials for each section from the foundation to the top before any erection is started. This will save a lot of time later.

### ASSEMBLY AND ERECTION OF SECTIONS

The first section of the tower is assembled on the ground alongside the foundation. Start by assembling the two-column legs on one side of the tower and bolt them loosely, with one bolt each, to two foundation stubs (anchor angle irons); these will act as pivot points. Next, loosely join the angle and the cross braces. Then lift the entire side. A crane or gin pole can be used to rotate it into a vertical position or, if necessary, it can be lifted by hand. Two people can start by lifting the far end and start walking it up. The two others, with handlines, can complete the upward journey.

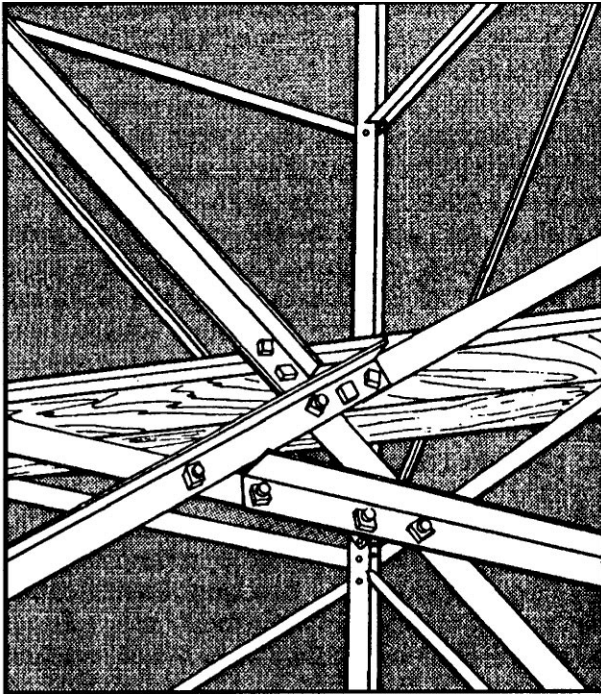
As the column legs fall into position, use driftpins or spud wrenches to line up the holes with the holes in the anchor angle irons. Then insert the bolts and tighten them. Use spud wrenches for this job. Place lock washers under each nut. When one side is standing in the upright position, repeat the process for the opposite legs. Finally, connect the cross braces on the open sides, and add the cross braces on the inside. When the whole first section, or bay, is in place, tighten the bolts. Figure 8-27 shows the correct connection of diagonal and center horizontal members; notice the alternate connections of the diagonal members at all points,

Use a snatch block and line to lift each piece for the next section. Do not tighten the bolts until the entire section is in place. Then start lifting the pieces for the next section, shifting the snatch block as necessary. When the whole section is in place, tighten the bolts. Repeat this process until the whole framework of the tower is erected. Bolts should be hoisted by handlines in buckets or leather-bottom bolt bags. Figure 8-28 shows a partially completed tower.



127.147

Figure 8-26.—Anchor angles in a concrete foundation.



127.148

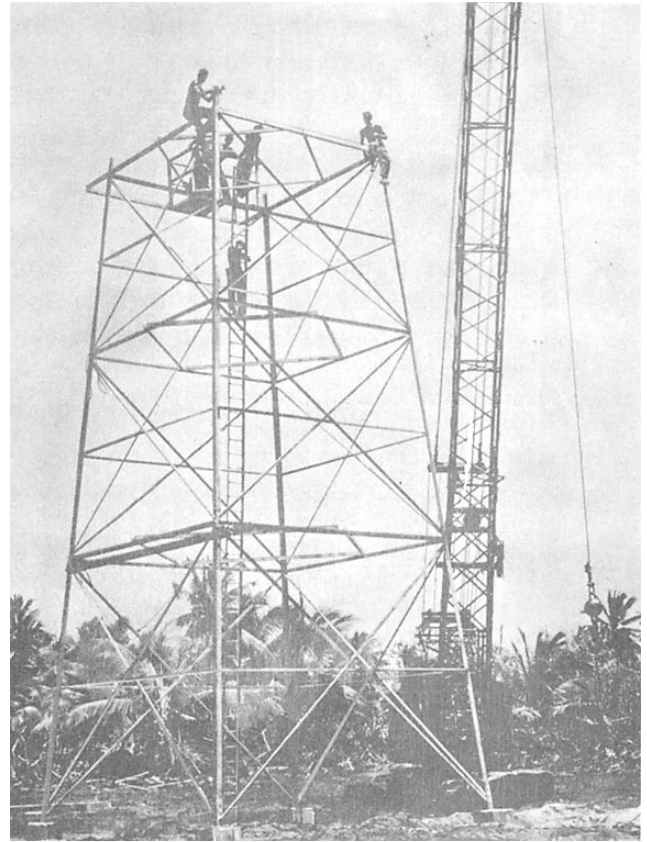
**Figure 8-27.—Connection of diagonal and center horizontal members.**

The ladder for the tower is assembled on the ground. As the tower is erected, the sections of the ladder are raised in place by handlines. These sections are then bolted in place. The cabin section is made of wood and is constructed by the Builders and raised in place; but, Steelworkers will be called upon to assemble rails and platforms.

After the tower is complete, one or two people must go over all of the bolts, center punching them to lock them in place. These people must also tighten all the nuts and see to it that washers have been inserted under each nut. This can be repeated after a few weeks as a final check. Figure 8-29 shows the top of a completed tower with a control room and with the guys in place.

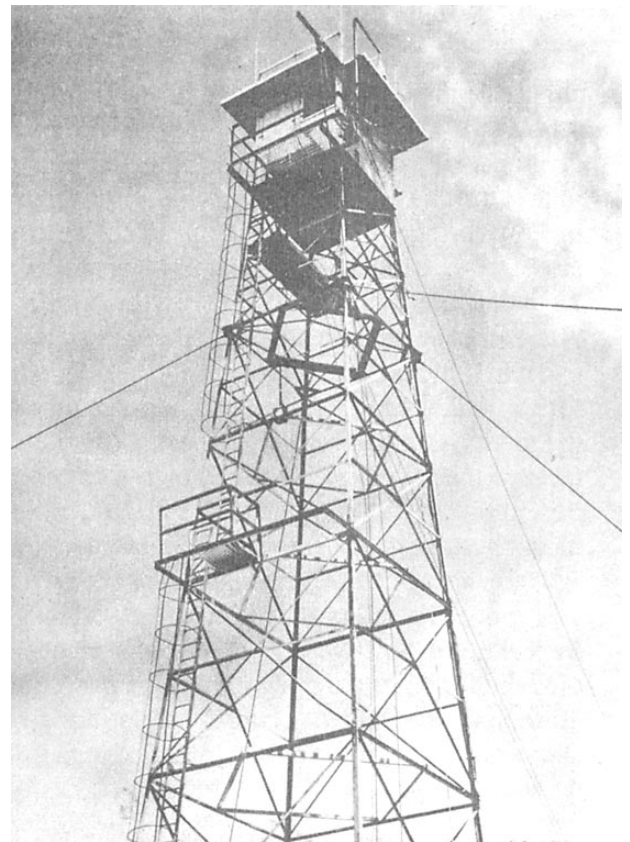
## **DISMANTLING A TOWER**

Steel towers can be taken down when they are no longer needed and then be erected again at a new location. As the first step in dismantling a tower, remove the guy lines, the electrical conduit for the red warning light for aircraft atop the tower, the platform, and any other accessories. Next, set up your rigging gear so that one leg of the section—preferably the leg that the ladder is connected to—will serve as the gin



29.178.1

**Figure 8-28.—Partially erected tower.**



29.178.2

**Figure 8-29.—Completed tower.**

pole. Proceed to attach a shackle to the top vacant hole in the gusset plate and have a snatch block in the shackle. Open the snatch block and insert the fiber line to be used as a hoist line. Tie a bowline in the end of the line to keep it from slipping through the block. Take the line to be used as the tag line and secure one end to the bowline. Now, secure a snatch block to the base of the tower, and run the hoist line from the top snatch block to this block. Be sure the snatch block at the base of the tower is located in a straight line to a source of power. The source of power can be a dump truck, a weapon carrier, or some other vehicle.

**NOTE:** When using a vehicle as a source of power, you must keep it back far enough so that as it comes forward, it does not arrive at the base of the tower before the load is on the ground.

The tower is dismantled by sections, and the top and second horizontal braces are the first members of the section to be removed. Start by tying the hoist line and tag line to the horizontal braces. Then signal the vehicle operator to back up and take a strain on the hoist line. You are now ready to remove the bolts, holding the horizontal braces in place. After all of the bolts are removed, lower the horizontal braces to the ground. Now, remove the diagonal braces in the same manner.

The next step is to remove the legs of the tower section, except the leg being used as the gin pole. First, shinny up the leg to be dismantled and hang a shackle at the top. Tie the hoist line to the shackle and then come back down the leg. Signal the vehicle operator to take a strain on the hoist line—just enough strain to take up the slack. Remove the gusset plate from one side. Remove the remainder of the bolts that hold the leg being removed, leaving the two top bolts in place. Now, take the tag line and secure it with a clove hitch and a half hitch to the bottom of the load. Also, take a turn with the tag line around the horizontal bracing in the section that will be removed next. You should then remove the two top bolts as you slack off on the tag line and take up on the hoist line until the leg is hanging straight up and down against the gin pole. Release the tag line to the personnel on the ground who will guide the load, as it is lowered to the ground. Repeat this process with all of the remaining legs until only the ladder and the leg used as a gin pole are left. To remove the ladder, secure the hoist line to a rung above the center. Remove the bolts and then lower the ladder to the ground.

When you are ready to start dismantling the leg used as the gin pole, shinny up the leg and remove the

hoist line from the snatch block. Secure the hoist line to the shackle. Remove the snatch block and hang it in your safety bit. Then come back down the leg to the spliced connection. (Generally, at all spliced connections, there will be horizontal brace connections that can serve as working platforms.) Signal the personnel on the ground to remove the hoist line from the base snatch block; then signal the vehicle operator to take up the slack. Remove the rivets and the gusset plate from one side of the splice. Remove the remaining bolts in the leg. After all of the bolts are removed, ensure that all personnel are clear of where the load will land. Remove the top bolt, and release the nut on the other bolt one-quarter turn. Signal the vehicle operator to back up slowly. As the operator backs up, the leg will pivot downward on the bolt and fall against the leg it has been standing upon and which will be used as the gin pole in dismantling the next section. Now, insert the shackle in the top hole of the gusset plate and hang the snatch block in it. Put the hoist line back in both snatch blocks. With the hoist line, throw a half-hitch below the center of the leg. Now secure the tag line. Next, signal the vehicle operator to give a slight strain to take the tension off the bolt. You can then remove the bolt and lower the leg to the ground. This completes the dismantling of an entire section of the tower, so you can proceed to the next section.

Repeat the above procedure with each section until the tower is completely dismantled.

If the tower will be put up again, rather than scrapped, a crew should be assigned to wire brush each member of the tower after it is lowered to the ground. In wire brushing, all rust, loose paint, and the like, should be removed from the member. Each member should also be marked. After they are marked, the members should be stored in an orderly manner.

## ANTENNA TOWERS

Modem communications in different parts of the world between ships, shore stations, and aircraft, including the United States aerospace efforts, have required that transmitting and receiving facilities be erected all over the globe. Many times the Steelworkers from battalion detachments will be assigned to erect them. This section will describe some of the common communications antenna towers that are erected and the procedures for erecting them.

## GUYED TOWERS

The most commonly used guyed towers are fabricated from steel in untapered sections 10 to 20 feet long. These constant dimensional sections are erected one above the other to form the desired height. Structural stability for this type of tower is provided by attaching guy wires from the tower to ground anchors.

Base supports for guyed towers vary according to the type of tower to be installed. Three commonly used base supports are the tapered tower base, the pivoted tower base, and the composite base. All three are shown in figure 8-30.

A tapered tower base concentrates the load from multiple tower legs to a small area on the foundation.

The pivoted base is used primarily on lightweight structures for ease of tower erection.

A composite base is generally used with heavier towers because it affords much greater supporting strength than the other two types.

Sections for lightweight towers are usually assembled before delivery, to expedite final tower assembly, whereas heavier weight towers must be assembled completely in the field.

Tower bracing should include diagonal bracing and horizontal struts in the plane of each tower face for the full tower height.

## FREESTANDING TOWERS

Freestanding, or self-supporting, steel antenna towers are characterized by heavier construction than guyed towers and by a shape that tapers in toward the top from a wide base. Freestanding towers exert much greater weight-bearing pressure on foundations than most guyed towers. Consequently, deeper foundations are required (because of the greater size, the weight, and the spread of tower legs) to provide sufficient resistance to the uplift. Each leg of a freestanding tower must be supported by an individual foundation. Figure 8-31 shows a typical individual foundation for a freestanding tower, and figure 8-32 shows a foundation plan for a triangular steel freestanding tower. Bracing and material specifications for these towers are the same as for guyed towers.

## TOWER ASSEMBLY

Advance planning for tower assembly and erection is essential for completion of the project safely and correctly. Both the installation plan and the manufacturers' instructions should be studied to gain a complete understanding of the tower assembly and erection methods to be used. The following general procedures and practices should be observed for the assembly and erection of towers:

1. Assemble the tower sections on well-leveled supports to avoid building in twists or other deviations. Any such deviations in one section will be magnified by the number of sections in the complete assembly.

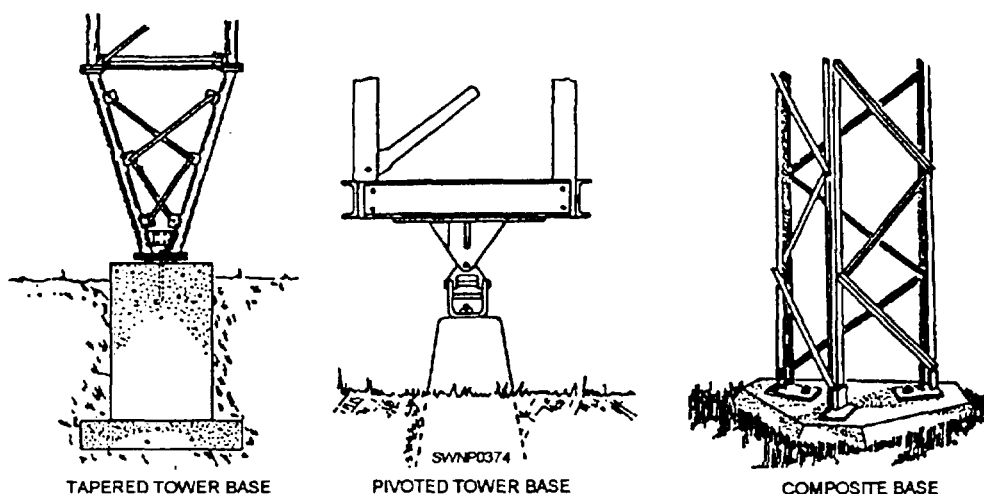


Figure 8-30.—Base support for guyed towers.

127.504

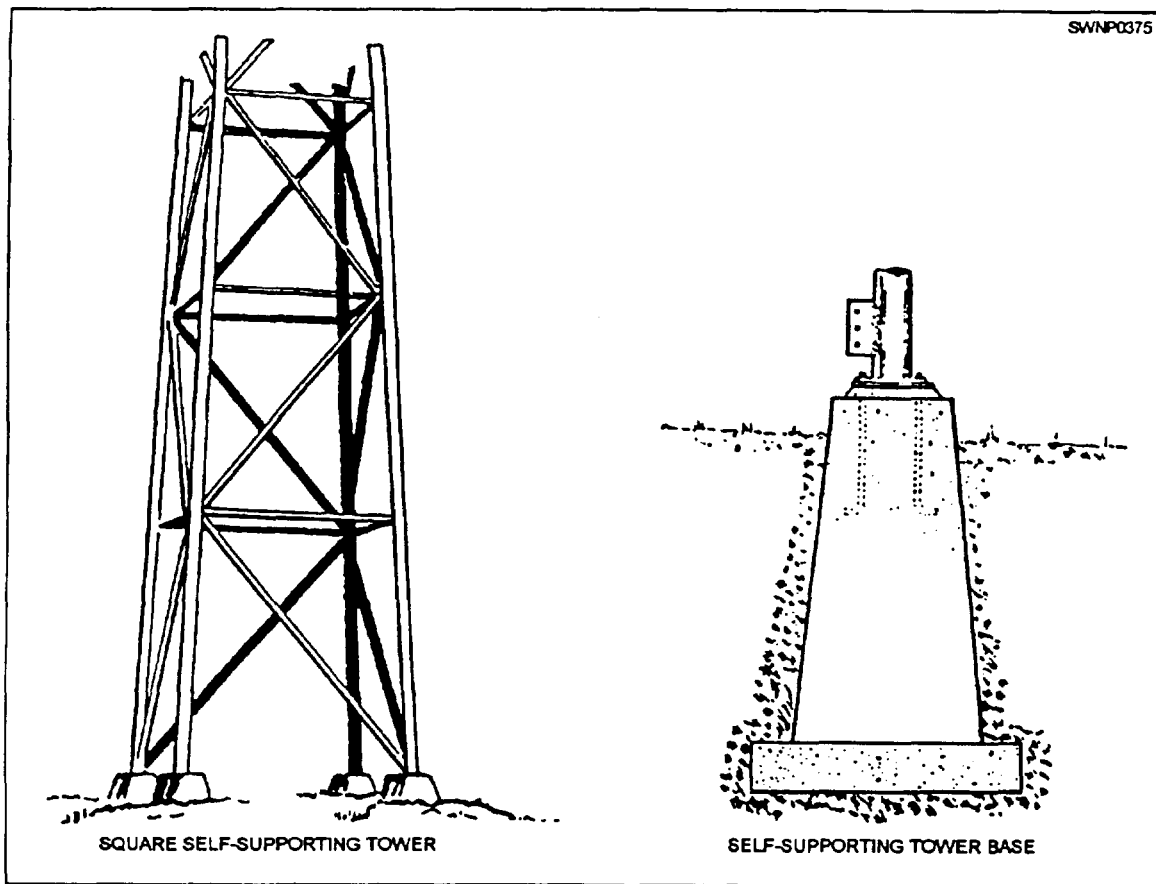


Figure 8-31.—Square self-supporting tower and base.

127.505

2. Check all of the surface areas for proper preservation. Cover all of the holes and dents in galvanized materials with zinc chromate or another acceptable preservative to prevent deterioration.

3. When high-strength bolts are used in a tower assembly, place a hardened steel washer under the nut or bolt head whichever is to be turned. Care must be exercised not to exceed the maximum torque limit of

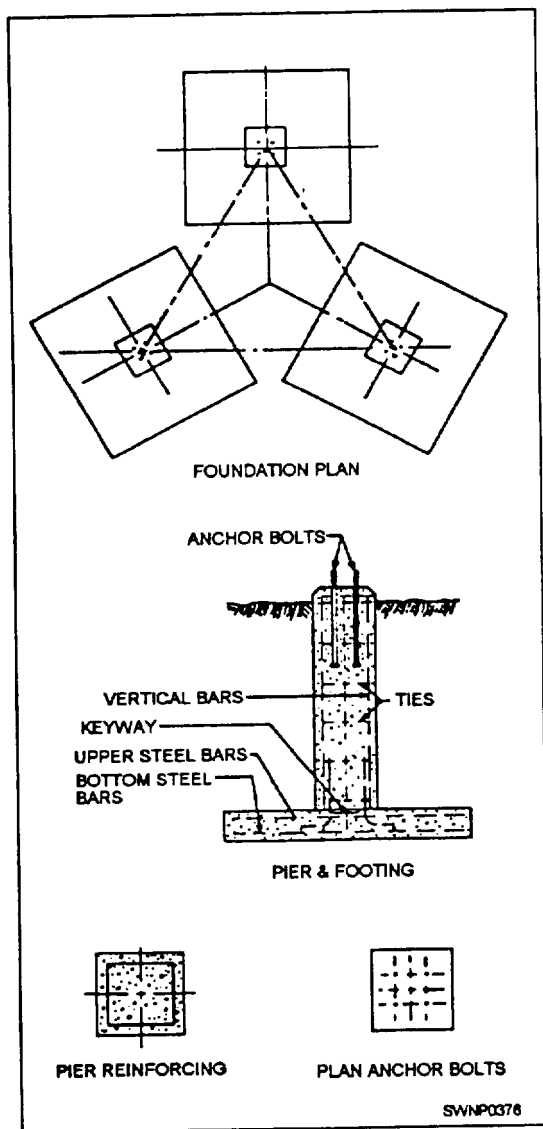
the bolt. Maximum torque values of several different sizes and types of bolts commonly used in antenna towers are listed in table 8-2.

#### ERECTION OF GUYED TOWERS

The following paragraphs present methods that have been successfully used to erect guyed towers. The most practical method for any particular tower

Table 8-2.—Bolt Torques (foot-pounds)

Size	Mild Steel	High-Strength Steel	Aluminum 24 ST-4	Stainless Steel 18-8
3/8" - 16- - - - -	17	- - - - -	12	30
3/4" - 13- - - - -	38	105	26	43
5/8" - 11- - - - -	84	205	60	92
3/4" - 10- - - - -	105	370	82	128
7/8" - 9- - - - -	160	530	184	194
1" - 8- - - - -	236	850	- - - - -	- - - - -
1-1/8" - 7- - - - -	340	1100	- - - - -	- - - - -
1-1/4" - 7- - - - -	432	1800	- - - - -	- - - - -



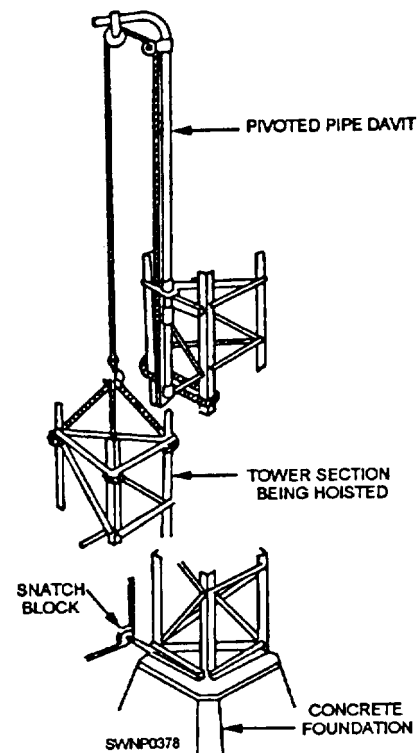
127.506

Figure 8-32.—Triangular tower foundation.

will be determined by the size, the weight, and the construction characteristics of the tower and by the hoisting equipment.

### Davit Method

Lightweight guyed towers are frequently erected with a davit hoist that is anchored to the previously erected section, providing a pivoted hoisting arm. The davit arm is swung away from the tower in hoisting the added section and swung centrally over the tower in depositing the section before bolting up the splice plates. Figure 8-33 shows a ground assembled unit being hoisted for connection to a previously erected tower section. A snatch block, secured to the tower base, transmits the hoisting line to a source of power



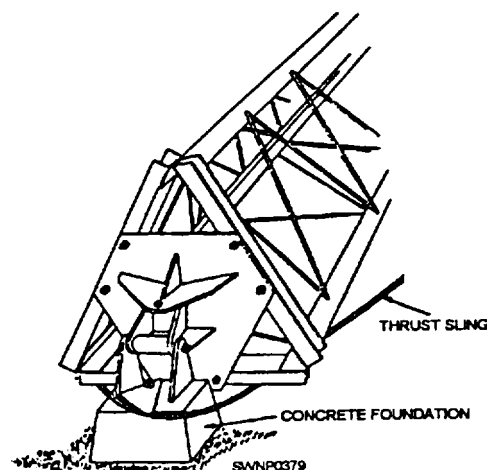
127.507

Figure 8-33.—Typical davit installation.

or hand winch. A tag line, secured to the base of section being hoisted, avoids possible contact with the erected portion of the tower.

### Gin Pole Method

Light triangular guyed towers, furnished with a pivoted base, may be completely assembled on the ground and then raised to a vertical position with the aid of a gin pole. Figure 8-34 shows the lower section



127.508

Figure 8-34.—Pivoted tower-hoisting preparation.

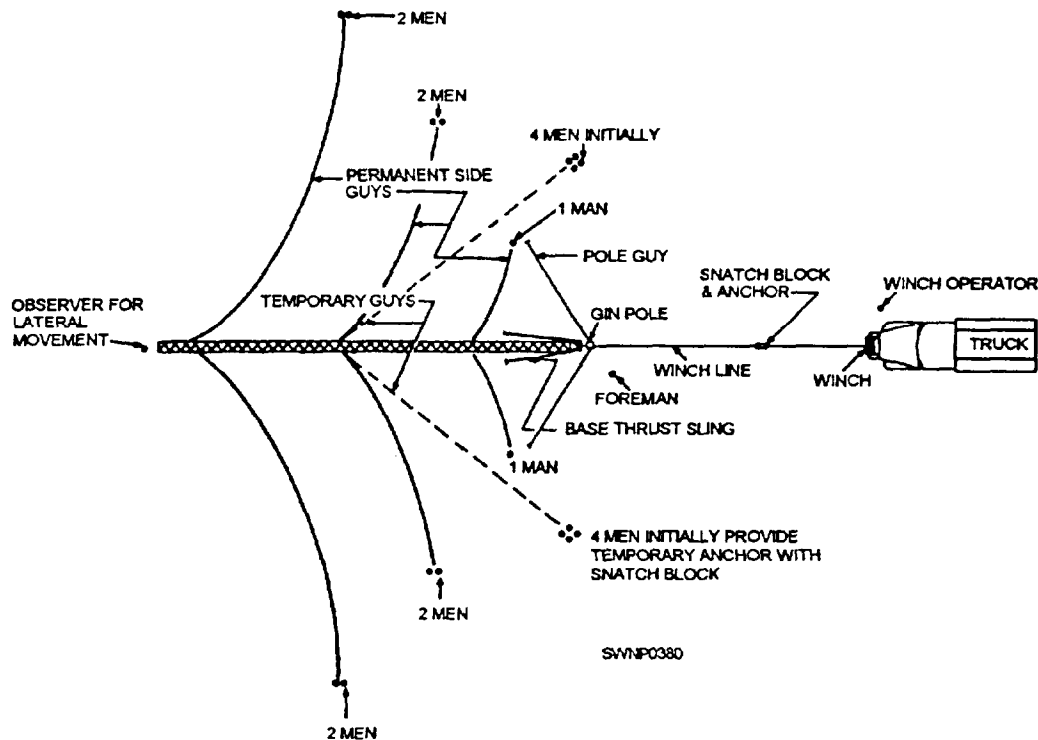


Figure 8-35.—Erection plan for a pivoted tower.

of a tower that has an attached pivoted base in a horizontal position preparatory to hoisting. The thrust sling shown counteracts the thrust on the base foundation from hoisting operations. Rigging operations and location of personnel essential to the raising of a pivoted base tower are detailed in figures 8-35 and 8-36. Light towers in lengths of approximately 80 feet may be raised with a single attachment of the winch line. However, longer towers

frequently are too flexible for a single attachment, and, in this case, a hoisting sling, furnished with a snatch block, allows for two points of attachment. The gin pole is mounted close to a concrete tower base and is provided with atop sheave to take the winch line. Permanent guys, attached to the tower at three elevations, are handled by personnel during hoisting operations, as shown in figure 8-35. Temporary rope guys, provided with a snatch block anchored to deadmen, furnish the necessary lateral

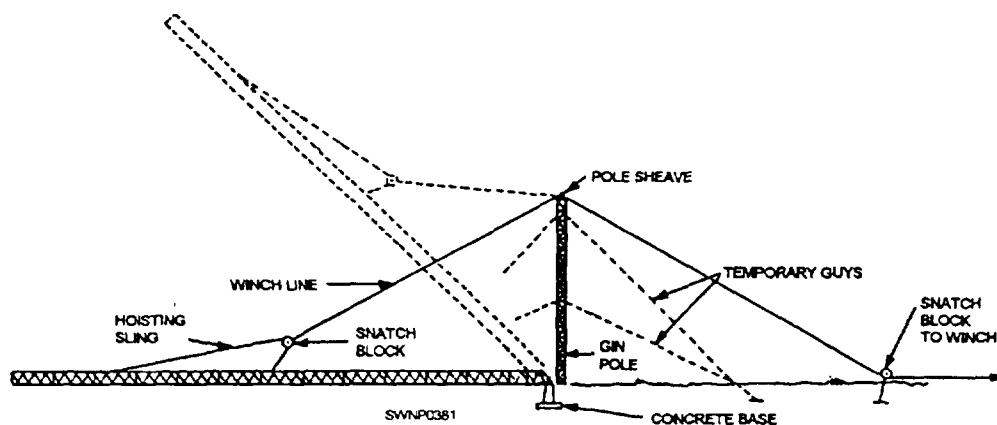


Figure 8-36.—Erection of a pivoted guyed tower.

127.510



stability As the mast approaches a vertical position, the permanent guys are fastened to the guy anchors installed before erection.

## Hand Assembly

Erection, without a davit or gin pole, may be accomplished by the assembly of the individual members piece by piece, as the tower is erected. As assembler, you climb inside the tower and work with the lower half of your body inside the previously assembled construction. You then build the web of the tower section around you, as you progress upward. As each member is bolted in place, you should tighten all of the connections immediately so that at no time are you standing on or being supported by any loose member.

## GUYING

Temporary guying of steel towers is always necessary where more than one tower section is erected. Under no circumstances should the tower be advanced more than two sections without guying. Permanent guys are to be installed before the temporary ones are removed.

### Temporary Guying

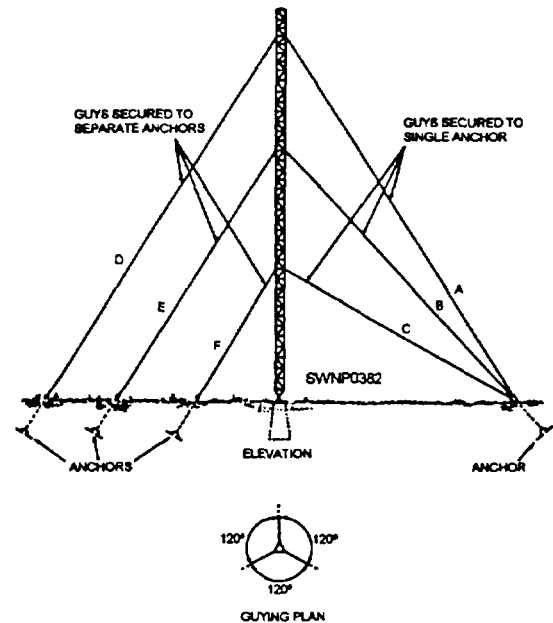
Several materials, including stranded wire, wire rope, and fiber line, are all acceptable for temporary guying. New manila line is the most suitable because of its strength and ease of handling. The size of the guyed material required is determined by the height and weight of the structure to be guyed and by weather conditions at the installation site.

Secure the temporary guys to the permanent guy anchors to temporary type anchors or to any nearby structure that provides the required supporting strength. Leave the temporary guys in place until the structure is permanently guyed and plumbed.

### Permanent Guying

Antenna structures are permanently guyed with steel cables or fiber glass sections to pre-positioned anchors according to the installation plan.

Figure 8-37 shows two methods of guying triangular steel towers. Guys A, B, and C are secured to a single anchor, while guys D, E, and F are secured to individual anchors. Both arrangements are satisfactory. However, the anchor that terminates guys A, B, and C must be capable of withstanding much greater stresses than the individual guy anchor arrangement. Triangular tower guys are arranged so



127.511

Figure 8-37.—Tower-guying arrangements.

that three guys are spaced 120 degrees apart at each level of guying (fig. 8-36). Square towers require four guys spaced 90 degrees apart at each level of guying (fig. 8-37). Square towers require four guys spaced 90 degrees apart at each guying level. The following general elevation requirements apply to guy attachments for towers:

**SINGLE-GUY LAYER** The cable attachments are placed in position at approximately two thirds of the tower height.

**TWO-GUY LAYERS.** For towers with two-guy layers, cable attachments are placed in positions at approximately 30 and 80 percent of the tower height.

**THREE-GUY LAYERS.** For towers with three-guy layers, cable attachments are placed in positions at approximately 25, 55, and 85 percent of the tower height.

### Tower Guy Tension

Setting guy tension and plumbing a tower are done at the same time and only when wind forces are light. Guy tension adjustment and tower plumbing are done as follows:

**INITIAL TENSION.** All of the guys should be adjusted gradually to the approximate tensions specified in the antenna installation details. If tensions are not specified, guy tension should be adjusted to 10 percent of the breaking strength of the strand of the

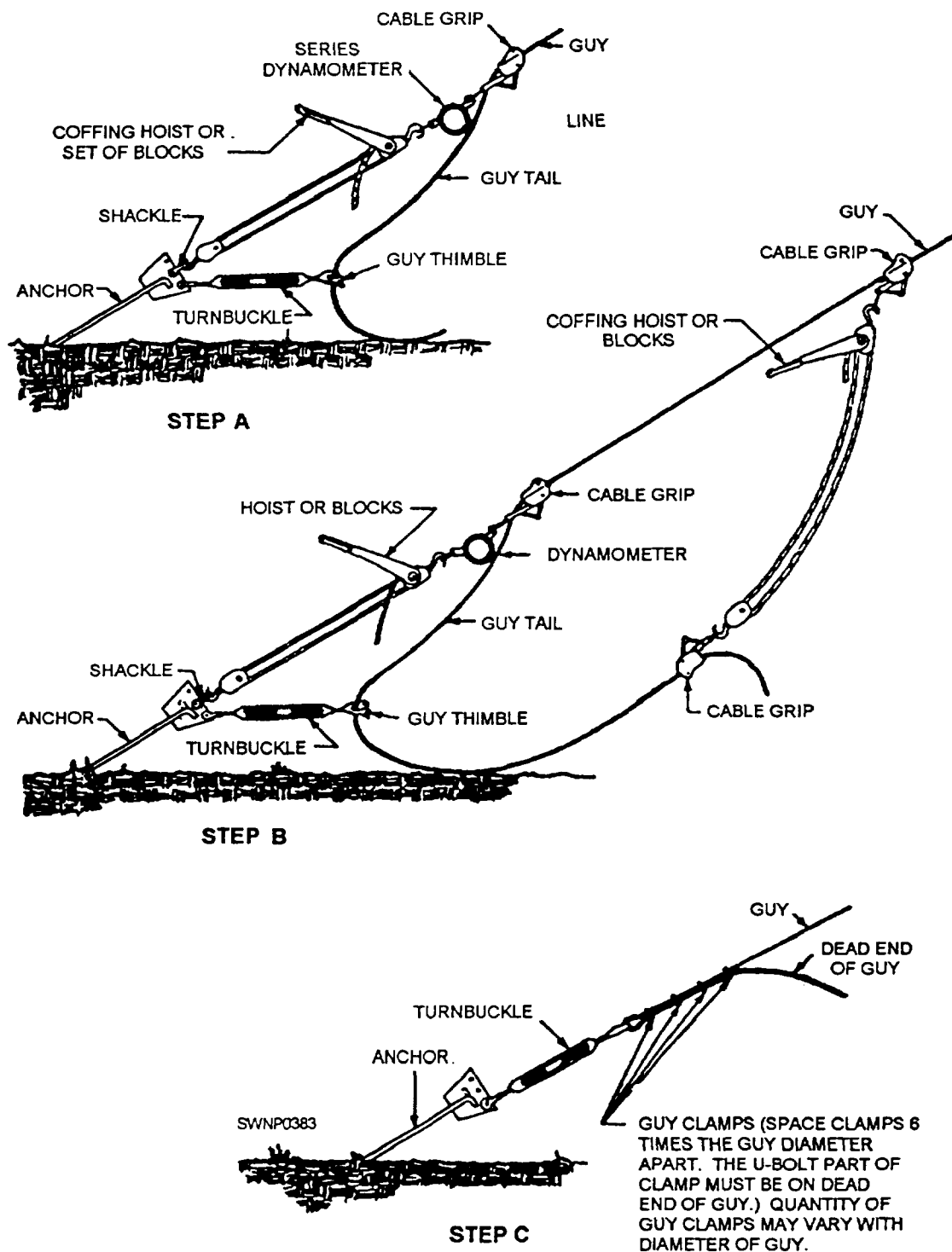


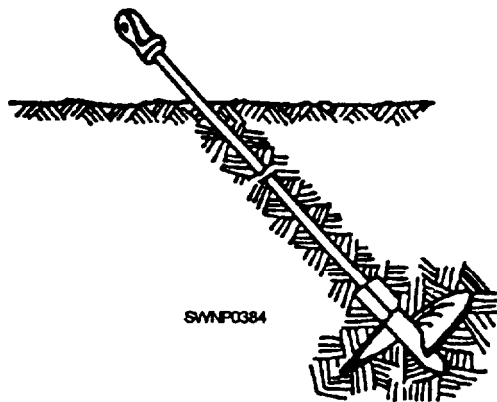
Figure 8-38.—Final tensioning of guys.

127.512

guy. The tension on all of the guys is adjusted after the tower is in a stable, vertical position.

**FINAL GUY TENSION.** In one procedure used for final tensioning of tower guys, the final tension is

measured with a dynamometer, as shown in figure 8-38. Carpenter stoppers or cable grips of the proper skin, designed for the lay of the wire, must be selected for use in the tensioning operation. Any cable grip assembly that grips the wire by biting into the cable



127.513

Figure 8-39—Typical screw anchor.

with gripping teeth could penetrate and damage the protective coating of guy cables and should not be used. In step A of figure 8-38, the coffering hoist is shown in series with a dynamometer to measure the tension. A turnbuckle is shown in position to receive the guy tail. In step B, an additional cable grip and hoist or tackle are attached above the cable grip shown in step A. The lower end of this tackle is provided with a second cable grip that is attached to the guy tail previously threaded through the turnbuckle. The second coffering hoist is operated until sufficient tension is applied to cause the reading on the series dynamometer to fall off. Step C shows the guy in final position secured in place with clamps. With the tower properly plumbed to a vertical position, only one guy at a given level need be tested with the dynamometer.

On some installations, other procedures for tensioning guys may be necessary because of the type of guys and hardware supplied with the antenna. For example, preformed wire helical guy grips are sometimes used for attaching guy wires to the adjusting turnbuckles. In such cases, the techniques used for the guy assembly, the connection of the guy wire to the anchor, and the tension adjustments must be determined for the detailed installation plan or the appropriate antenna technical manual.

### Guy Anchors

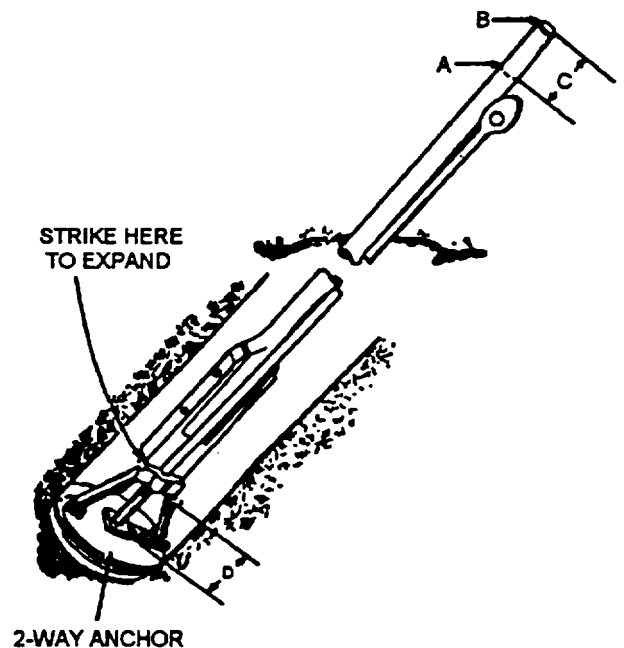
Antenna design and installation plans specify the anchor type, the location, and the hole depth required.

Anchor shafts, or rods, must project above the grade sufficiently to keep all of the connecting guy wire attachments free of vegetation and standing water. Shafts and connecting attachments should be thoroughly cleaned and then coated with a petroleum preservative to retard the effects of weather.

**SCREW ANCHOR.** The screw anchor shown in figure 8-39 may be used for temporary guying and for anchoring guys for lightweight towers. This anchor is installed by screwing it into the ground in line with the direction the guy will take.

**EXPANSION ANCHOR.** The expansion anchor shown in figure 8-40 is suitable for practically all guying applications where the soil is firm. This anchor is placed with its expanding plates in the closed position in an auger-drilled inclined hole, not less than 3 feet deep. The plates are expanded into the firm, undisturbed sides of the hole by striking the expanding bar at point B with a hammer and thereby forcing the sliding collar downward the distance D shown in figure 8-40. The anchor installation is completed by backfilling the hole with thoroughly tamped backfill.

**CONCRETE ANCHORS.** Poured in-place concrete anchors are normally used for high stress applications and where multiple guys are attached to a single anchorage.



SWNP0385

### LEGEND

- A = EXPANDING BAR
- B = HAMMER STRIKING POINT
- C = MOVEMENT DISTANCE OF EXPANDING BAR
- D = MOVEMENT DISTANCE OF SLIDING COLLAR

127.514

Figure 8-40.—Expansion anchor.

